POWER

Volume 59 New York, March 11, 1924 *No.* 11

Tenacity

THE hardest part of doing some jobs is holding the work.

The tenacious old vise that does not go through any motions or make any noise, but just grips and holds the tortured metal still does not get half the attention or credit that the noisy file or hammer and chisel do.

There are men like the vise. Grim, silent, determined, doing the job set for them without fuss or feathers, making the work of the lighter weights possible.

There are men like the file. The duller and less effective they are, the more fuss and noise they make and the more direction and pushing they need to get through a job.

But when you get a combination of the strong, purposeful master with his powerful grip always on the main purpose and a crew of bright, sharp assistants working that purpose out, whether that purpose be the running of a power plant or what not, things will sail.

F. R. Low

Revamping Municipal Electric Plant at Hannibal, Mo.

REVAMPING a Corliss engine condensing plant and installing an additional boiler, a new turbo-generator to carry the bulk of the load and coal and ash-handling equipment, resulted in reducing the steam consumption per unit of output 40 per cent, the amount of coal burned in nearly the same proportion and a 24 per cent reduction in labor costs.

SINCE the management of the municipal plant at Hannibal, Mo., was placed in the hands of the Board of Public Works in 1903, no part of the general taxes of the city has been used for its support. All bonds, interest and improvements have been paid from the earnings of the plant, and in addition, operating profits, which exceeded $30,000 for the last year, were allowed to accrue to take care of replacement of equipment or to add to the capacity of the plant. It has not been due to unusual economy, for until Jan. 1, 1923, the equipment was ordinary, consisting of a cross-compound condensing Corliss-engine plant of the type installed twenty years ago, carrying a widely varying load, so that the economy for the most part was below present-day standards.

For the year ended May 31, 1923, the load totaled 5,258,720 kw.-hr. The steam and electric generation expenses are shown in Table I. The maintenance items here are heavier than usual owing to the revamping of the plant, and the other items are perhaps a little higher than the average by reason of the inconvenience caused by the reconstruction work.

The total operating receipts for the year, amounting to $195,128.93, were obtained with the following rates for electric service: The base lighting rate is 8c. per kw.-hr. with a 10 per cent discount for bills ranging from $1 to $5, thus reducing the net rate to 7.2c. per kw.-hr. and a 20 per cent discount on bills ranging from $5 to $10, giving a net rate of 6.4c. per kw.-hr. All current in excess of $10 gross is sold at 6c. for each kilowatt-hour, net.

For intermittent power service the base rate is 5c. per kw.-hr., subject to a graduated scale of discounts, making a net rate of from 5 to 3c. per kw.-hr. according to the monthly consumption. For manufacturers having a monthly consumption of 500 kw.-hr. or more the base rate is 3c. per kw.-hr. with a graduated scale of discounts making a net rate of 2.55 to 1.8c. per kilowatt-hour.

In 1921 it became evident that the capacity of the plant must be increased. The Arnold Co., consulting engineers, of Chicago, were called in to take charge of the work. What was done to effect large reductions in the coal and steam consumption and 24 per cent in labor cost, may be of interest.

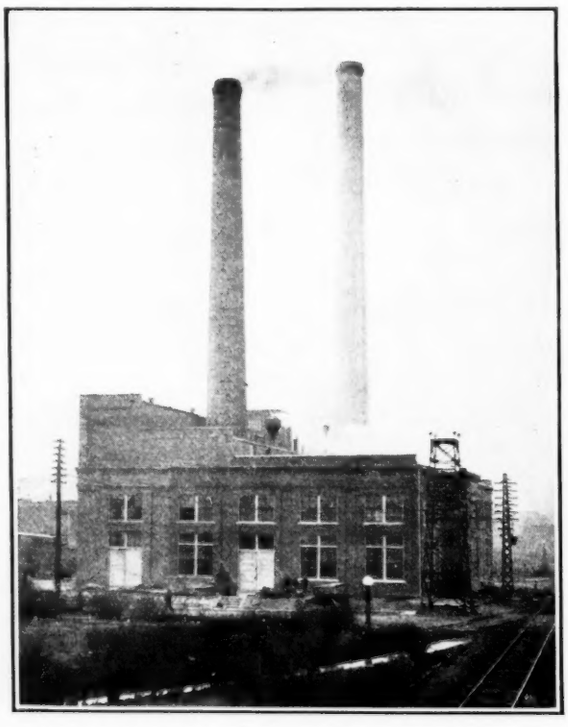


Fig. 1—Exterior of remodeled municipal plant at Hannibal, Mo.

In the old plant the generating equipment consisted of one 600-kw. and two 400-kw., 2,200-volt three-phase 60-cycle alternating-current generators driven by cross-compound Corliss steam engines equipped with low-head, jet-type condensers, the condensing water being drawn from the Mississippi River at a distance of approximately 150 ft. from the engine room. To supply steam to the generating units, there were three 2,800-sq.ft., and one 3,200-sq.ft. Stirling boilers set in batteries of two, the smaller boilers being installed in 1904 and the larger boiler in 1914. Recently, all these boilers had been equipped with natural-draft stokers of the Roney type. The draft was supplied by a brick stack 7 ft. in diameter and 155 ft. high, midway between the two batteries..

Coal was delivered in railroad cars on a siding next to the plant and shoveled into an outside bunker, from which it was shoveled through openings in the boiler-room wall into the stoker hoppers. The coal, as well as such other coal as was stored immediately north of the plant, was not unloaded by the regular boiler-room crew but by outside labor costing 10c. per ton of coal unloaded.

Ashes were raked out from underneath the stokers and with wheelbarrows were removed from the boiler-room floor to a dumping space on the grounds. At intervals the ashes were hauled away by the railroad company free of cost to the plant.

At the time the remodeling was being considered, late in 1921, the electric load varied from a minimum of 200 kw. to a maximum of 1,300 kw., the average load running from 900 to 1,100 kw. for about nine hours a day during the winter season and somewhat less during the summer. During December, 1920, peak loads of 1,300 kw. had been recorded, and in September, 1921, loads of 1,200 kw. had occurred several times, so that it was probable that the load in December, which had always been the heaviest month in the year, would exceed 1,300 kw. and might reach 1,500 kw. With a generating capacity aggregating 1,400 kw. it was evident that a temporary shutdown of one of the generating units would necessitate operation at heavy overloads on the others or it would be nec-

essary to cut off service during the peak period. For example, if the 600-kw. unit should be out of service temporarily, no demand larger than 1,000 kw. could be met.

To provide a proper reserve, it was suggested that the plant should carry its maximum load with one generator out of service. To meet this condition required the installation of another machine that would be large enough to care for the increase in plant load, averaging in the last few years about 8 per cent per annum. It was evident that the maximum load that the plant could carry until a second unit was added, would be the maximum generating capacity of the three engine units, inasmuch as the proposed new turbo-generator might be out of service at any time. Basing the maximum capacity of the three present machines on their overload ratings, approximately 1,800 to 1,900 kw. could be carried for two hours without difficulty. To equal this capacity in the event that the present 600-kw. unit should be out of service, the proposed new unit should not have less than 800 to 900 kw. in maximum rating. A turbo-generator was favored over a reciprocating engine unit, owing to the lower total operating expense including the overhead charges on the investment.

Relative Economy of 1,000-Kw. and 1,500-Kw. Turbines

The nearest standard size of turbine to the capacity required was 1,000 kw., and while this size of unit was well adapted to the load at that time, for all loads above 1,000 kw. one or more of the engine units would have to be operated in addition to the turbine. To determine the relative economy of a 1,000-kw. unit as against a 1,500-kw. machine operating in conjunction with the engine units, estimates were made of the steam consumption for the entire plant for an assumed average yearly load for the succeeding five years and for both sizes of turbine. The result of this estimate showed less than one per cent difference in the total

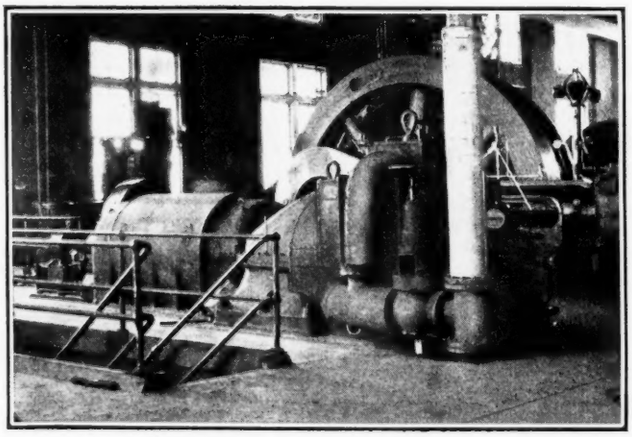


Fig. 2—New turbine unit in foreground

steam consumption during the year. The estimates indicated that after the first five years the 1,500-kw. unit would be more economical and save from $1,400 to $1,500 annually in coal expense. In investment cost the difference in favor of the 1,000-kw. unit was about $12,000, all of this saving occurring in the cost of the machine itself, since no saving could be made in the building extension and relatively little in the foundation, piping and cabling. The saving in fixed charges for interest and depreciation due to a smaller investment expense was placed at $1,200 a year on the basis of 10 per cent on the investment, or a total of $6,000 for the first five years. At the end of this period it was thought that it would be necessary to install additional generating equipment, so that the saving due to the smaller investment in the 1,000-kw. unit could no longer be credited. For the remainder of the life of the 1,000-kw. unit it would cost more to operate per kilowatt-

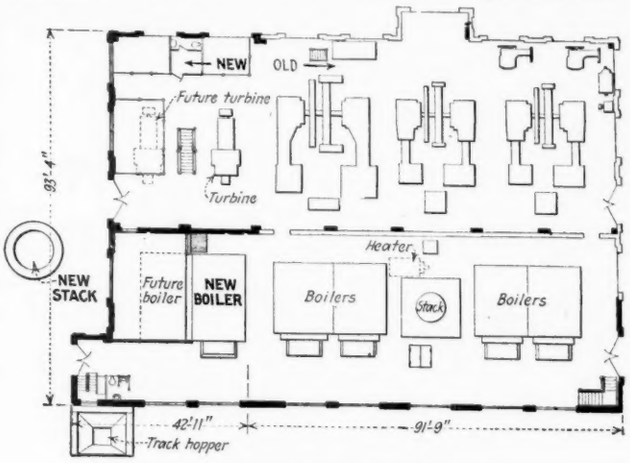


Fig. 3—Plan of remodeled station

hour of output than for a 1,500-kw. machine, and thus offset the saving made during the first five years. These considerations led to the installation of the larger machine with space in the remodeled building for another turbo-generator of the same size.

An investigation of the steam requirements of the plant disclosed that while the guaranteed water rates for the engines were from 20 to 21 lb. per kw.-hr. under the steam pressure and vacuum conditions existing at the plant, the actual rate was not less than 32 lb. per kw.-hr. The fuel, including the necessary coal for banking boilers and excess coal because of high water rates during light loads, averaged for the year 6.73 lb. per kw.-hr. This led to a complete revamping of the older equipment including the engines, boilers and pumps, with attention to the valves, pipe covering where damaged, etc.

Additional Boiler Decided On

While such action would tend to reduce the amount of steam and coal required, it was found that with a load of 1,500 kw. on the plant, all the boilers would have to be operated at overload ratings. Under these conditions, as one boiler should be out of service for cleaning and reserve, it was considered advisable to install an additional boiler containing 5,000 sq.ft. of steam-making surface, equipped with a natural-draft chain grate, in order to provide proper capacity and some reserve for the future.

To accommodate the new equipment, the building was extended sufficiently to allow for the installation of a second turbine of the same size and a second 5,000-sq.ft. boiler. With the installation of these two units, it was felt that the plant would have a capacity sufficient for approximately ten years' growth, as even with one of the turbines in reserve, 3,000 kw. could be developed, or 100 per cent more than the present maximum load on the plant. If the load developed faster than anticipated, additional capacity could be provided without a building extension by removing the engine units and installing

turbo-generators in their place and by replacing the older boilers with new units having greater capacity but occupying no greater floor area.

In considering the building extension, it was found that the width and height of the existing turbine room could be maintained for the extension, although the basement had to be modified for the new condensing equipment and special columns provided to support a new traveling crane.

With the new boiler higher than the older equipment, it was not possible to maintain the old truss height in the boiler room, and as it was necessary to provide space for overhead coal bunkers and a basement for ash han-

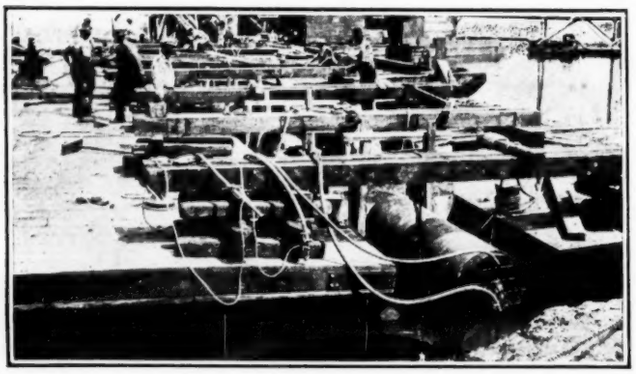


Fig. 4—Method of lowering condenser intake line

dling, the boiler room was increased in width but not sufficiently to interfere with the railway track bringing in the coal. In addition, an ash alley was provided under the firing aisle of the older boilers and the ash hoppers of the stokers remodeled for basement delivery. New overhead bunkers were extended over the older section, so that the coal- and ash-handling system would be available to the entire boiler room.

The New Coal-Handling System

The coal-handling system consists of a track hopper, a reciprocating feeder and coal crusher discharging into a continuous-bucket type of elevator, which in turn discharges through a chute onto a 16-in. belt conveyor equipped with an automatic tripper for distributing the

TABLE I—OPERATING COSTS FOR YEAR ENDED MAY 31, 1923

Steam Generation Expense:	
Coal	$89,935.57
Salaries and wages	12,147.70
Supplies and expense	937.84
Steam generation maintenance	5,952.28
	$108,973.39
Electric Generation Expense:	
Salaries and wages	$11,121.20
Oil, waste and packing	1,791.54
Other engine room supplies	258.42
Water	789.98
Electric generation maintenance	1,281.29
	$15,242.43

coal uniformly over the length of the bunkers. The coal-handling system has a capacity to handle 40 tons of coal an hour and is motor-driven throughout. In the overhead bunkers there is capacity to store 350 tons of coal. A one-ton traveling scale weighs the coal on its way to the stoker hoppers.

Ashes are now raked from the stoker hoppers and loaded into industrial cars in the basement and are delivered into the boot of the bucket elevator that handles the coal. By means of a suitable valve in the discharge chute at the top of the elevator, the ashes are delivered to a bunker inside the boiler room and spouted to the cars on the railway siding. Other new equipment added to the boiler room is an open feed-water heater equipped with a V-notch meter having a capacity of 80,000 lb. per hour. Feed-water regulators were installed at the boilers to control the feed, but the installation of new feed pumps just previous to the remodeling program made it unnecessary to increase the pump capacity. Steam-flow meters and CO_2 recorders were installed as guides to more economical operation in the future.

TABLE II—COAL CONSUMPTION BEFORE AND AFTER

	Output, Kw.-Hr.		Coal, Net Tons		Coal, Lb. per Kw.-Hr.	
Months	1921	1923	1921	1923	1921	1923
January	389,400	532,340	1,600	.....	8.22	....
February	349,700	451,140	1,400	.....	8.01	....
March	384,500	481,690	1,400	.....	7.28	....
April	341,100	462,400	1,100	943	6.45	4.08
May	337,500	464,000	1,150	869	6.81	3.74
June	322,700	414,300	1,050	819	6.51	3.95
July	356,400	442,210	1,100	1,038	6.17	4.69
August	396,800	484,960	1,200	1,100	6.05	4.54
September	415,600	459,100	1,350	1,068	6.50	4.65
October	449,400	535,800	1,450	1,053	6.45	3.93
November	453,800	521,000	1,350	1,116	5.95	4.28
December	468,960	548,600	1,500	1,163	6.40	4.24
Total	4,665,860	5,797,540	15,650	9,169	Av. 6.73	4.23

To serve the new boiler and future boilers of the same size, a new concrete chimney was built. The diameter at the top is 9 ft. and the height is 200 ft. above the boiler-room floor. The old chimney was retained to serve the original installation.

New Turbine Equipped with Surface Condenser

While low-head jet-type condensers serve the engines, it was decided to equip the new turbine with a surface condenser containing 3,000 sq.ft., or 2 sq.ft. per kilowatt of unit rating. The auxiliaries consist of a 14-in. steam-turbine-driven circulating pump having capacity to deliver 3,400 gal. per min., a two-stage steam-jet air ejector of the intercooled type and a 3-in. motor-driven condensate pump.

To provide sufficient cooling water at all stages of the river and to conform to government requirements, it was necessary to extend the intake line out into the river far enough to insure a depth of 6 to 8 ft. of water over the inlet at all times. The inlet is protected by a special iron crib screened by means of boiler tubes. Tapering ends obviate interference with floating logs. The distance from the inlet to the plant now approximates about 300 ft., one half of the line lying in the river bed and the other half in a trench from the shore line to the plant.

A 24-in. line of cast-iron pipe with bell-and-spigot joints was considered large enough to provide water for an output of 3,000 kw. Carrying this line out into the river for 150 ft. presented an interesting problem.

TABLE III—COMPARATIVE LABOR COSTS

1921 Crew		1923 Crew	
One chief and 3 watch eng.	$7,890	One chief and 3 watch eng.	$7,620
Three oilers	4,752	One oiler	1,584
Five firemen	8,280	Three firemen	4,968
One boiler cleaner	1,584	Three firemen's helpers	3,456
One ash handler	1,656	One boiler cleaner	1,584
Unloading coal at 10c. per ton rehandling from sotrage, car service, etc.	2,663	One coal handler	1,200
			$20,412
Total labor per year	$26,825		

After a dredging outfit had prepared the trench for the pipe, the 24-in. line was made up on scows, the joints calked and the line suspended from timbers resting on parallel rows of scows, as indicated in Fig. 4. The ends were sealed by covers made of planking. To sink the line gradually to place, water was allowed to replace the air slowly. The dredging outfit was again called into service to bed the pipe.

With a sheet-piling dam to shut off the water, a trench was dug from the shore line to the plant and the piping continued to the circulating pump in the basement. A return line, also 24 in. in diameter, is carried in the same trench, but near the shore line branches off to discharge the water downstream about 60 or 70 ft. from the intake. The under-water section of the discharge line was laid in the same way as the intake piping.

As to the results obtained from the remodeling and installation of the new turbine unit and boiler, Table II compares the output of the plant and the coal consumption for the years 1921 and 1923, the former year being taken in preference to 1922, as this was the reconstruction period during which operating data varied somewhat from normal. The new unit was ready for operation by January, 1923, but the coal scale weighing the fuel as it passes to the boilers was not installed and ready for use until April 1. For this reason the coal weights for the first three months of 1923 have been omitted. Reference to the table will show that coal for all purposes averaged 6.73 lb. per kilowatt-hour in 1921 and 4.23 lb. in 1923, showing that the remodeled plant effected a saving in coal consumption per unit of output of 37 per cent. The lower steam rates of the generating units and more modern boiler and furnace settings made this possible.

TABLE IV—NEW EQUIPMENT ADDED TO PLANT

One boiler	D. Connelly Boiler Co.
Surface, sq.ft.	5,000
Operating pressure, lb. per sq.in.	1,751
Superheat, deg. F.	100
One stoker, natural draft, chain grate	Illinois Stoker Co.
Surface, sq.ft.	108
Ratio to boiler-heating surface	1 to 46
Meter, steam and air flow	Bailey Meter Co.
Soot blowers (Valve-in-head type)	Diamond Power Spec. Co.
Superheaters (Foster)	Power Specialty Co.
One chimney, concrete	Heine Chimney Co.
Diameter at top, ft.	9
Height above boiler-room floor, ft.	200
One heater, open, weir-notch meter	H S B W-Cochrane Corp.
Capacity, lb. per hr.	80,000
Coal handling equipment	Weller Mfg. Co.
Consisting of track hopper, reciprocating feeder, coal crusher, bucket elevator, 16 in. belt conveyor and tripper, 1-ton traveling scale. Equipment, motor driven. Capacity of system, tons per hour	40
One turbo-generator	Westinghouse Electric & Mfg. Co.
Capacity, kva.	1,875
Generator	2,300-v., 3-phase, 60-cycle
Speed, r.p.m.	3,600
Condenser and auxiliaries	Westinghouse Electric & Mfg. Co.
Surface, sq. t.	3,000
Circulating pump, 14-in., turbine-driven, gal. per min.	3,400
Air pump	Two-stage steam-jet ejector, intercooled type
Condensate pump	3-in. cent., driven by 10-hp. motor
Switchboard	General Electric Co.
Crane, 10-ton, hand power, traveling	Northern Engineering Works

Savings Estimated at 45 to 50 per Cent

The foregoing percentage, however, does not give full credit. During the first three months of 1921 the fuel was Springfield screenings, but for the succeeding nine months a much better fuel, Franklyn County coal, was burned. In 1923 the fuel used was again Springfield screenings or the equivalent, so that on an equitable fuel basis the actual saving probably would have ranged from 45 to 50 per cent.

No definite figures are available on the steam consumption, but it will be recalled that estimates made in 1921 indicated a steam consumption for all purposes of at least 32 lb. per kilowatt-hour. With the new turbine carrying the bulk of the load, a material reduction is to be expected. This machine is guaranteed to deliver a kilowatt-hour on less than 16 lb. of steam. Allowing 2 lb. for condenser auxiliaries and the boiler feed-pumps, the steam consumption would be something under 18 lb. per kilowatt-hour. Owing to variations in the load and some interchange with the engine units, it is probable that the gross figure would approximate 20 lb. per kw.-hr., thus indicating a reduction approximating 40 per cent.

In labor it was possible to eliminate one man within the plant and, outside, the crew that had been employed specifically for unloading coal at the rate of 10c. per ton. As the changes in the plant varied the daily routine, it was possible also to make some reduction in wages, so that the total expense for plant labor was $6,413 lower in 1923 than in 1921, a reduction of 24 per cent. This in combination with a saving of 40 per cent in steam consumption per unit of output and the saving in coal amounting to 37 per cent, indicates the possibilities in remodeling older plants and bringing them up more nearly to present standards.

Waterwheel Buckets Built Up by Welding

An application of oxyacetylene welding that is finding increasing usefulness in hydro-electric plants is the building up of worn or corroded buckets in cast-iron or bronze turbine wheels. The "putting-on tool," as the welding blowpipe is known in some shops, effectively replaces metal worn from the buckets in service, rendering them as good as new and in many cases even preparing the buckets to withstand wear and corrosion better than new castings.

An extra value of the oxyacetylene process for repair work of this nature lies in the fact that it is economical to restore damaged sections to their normal condition while the defect is still in its early stages. It is not necessary to postpone action until replacement is rendered imperative by the condition of the buckets. Small defects can be repaired at any convenient time.

Many hydro-electric plants find that it is profitable for them to maintain an oxyacetylene welding outfit on hand for this work. However, there is so much work around such a plant that is handled to advantage with the oxyacetylene welding and cutting blowpipes that substantial savings are made even when only a few opportunities for applying this process in other lines are understood.

Any plant, even if it is not equipped with oxyacetylene apparatus, can take advantage of the savings afforded by this process when the occasion arises. In nearly every industrial community there is an experienced and competent job-welding organization which, if it has not handled the particular type of work under consideration, has contact with the larger manufacturers of welding apparatus and gases who will furnish dependable engineering advice and operative assistance to their customers on large or unusual applications.

Such were the conditions surrounding the repair of the waterwheels at the Bulls Bridge power plant of the Connecticut Light & Power Co. These cast-bronze wheels, one of which is shown in Fig. 1, had become so corroded in use that they ceased to function properly. If not repaired or replaced in a short time, they would have become worthless. It was impossible to replace them except at high cost and with a delay of many weeks, and it would have required making a new pattern from one of the old wheels before the castings could be made. It was decided, therefore, that it would

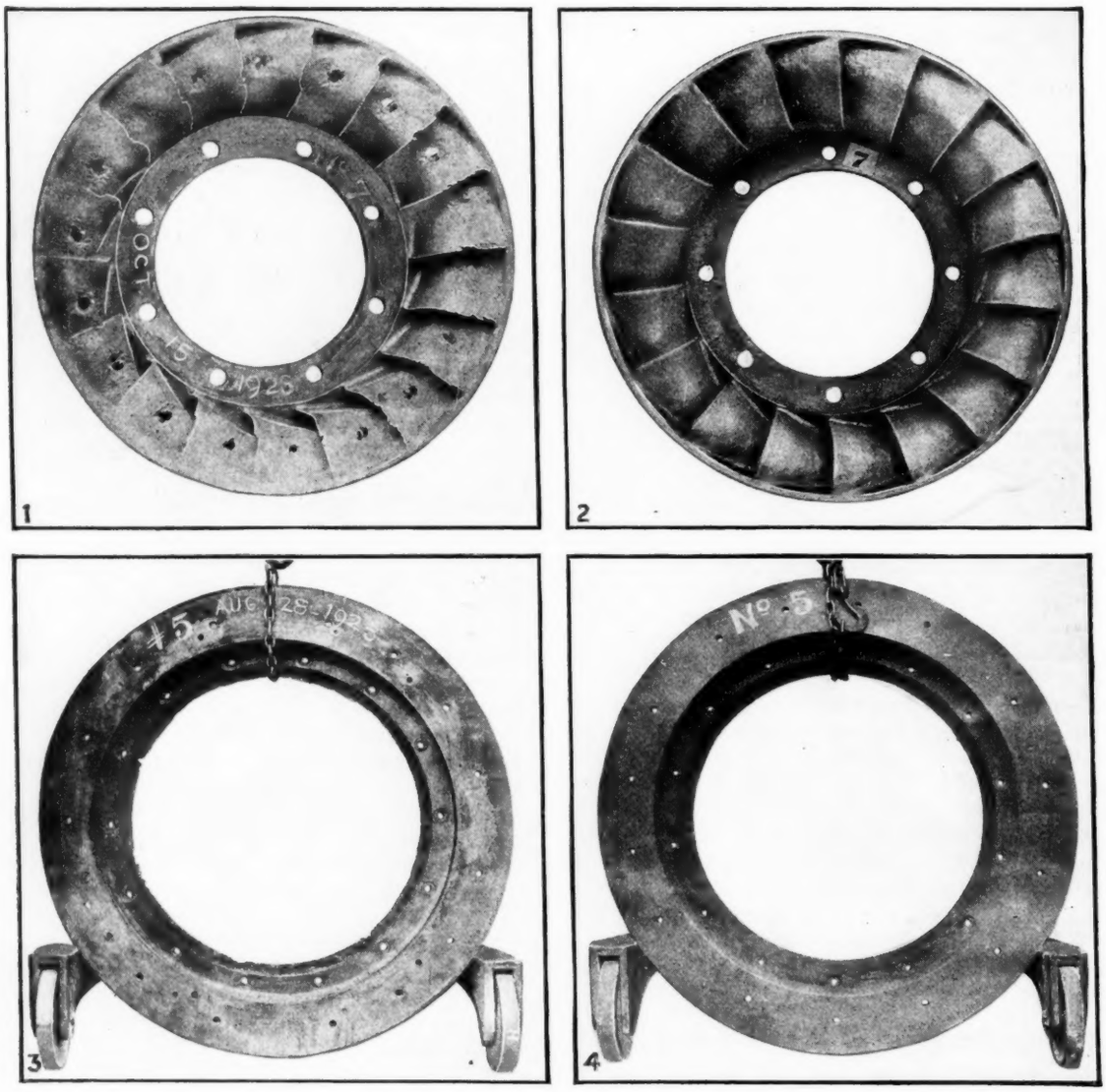
be impracticable under these conditions to replace the wheels, and oxyacetylene welding was decided upon as the means to repair them.

The wheels are 4 ft. outside diameter, have an 18-in. face and weigh about 700 lb. each. Each wheel has 18 buckets, every one of which had to be repaired. The extent to which they were worn away is clearly shown in Fig. 1.

A local job-welding company was asked to undertake the repairs, and the condition of the buckets made it advisable to remove the wheels from their casings and preheat them before welding. This procedure made the cost of welding lower than it might otherwise have been, because through the preheating the time required for welding was materially reduced.

A tobin-bronze welding rod was used in building up the damaged sections, about 1 lb. being necessary for each bucket. When the welding was completed, the wheels required no finishing, but were in condition to be placed back into service immediately. Fig. 2 shows the wheel, Fig. 1, after welding and gives an indication of the satisfactory appearance of the finished job.

The same action that had affected the buckets on the waterwheels had also acted on the internal circumference of their cast-iron housings. One of the damaged castings is shown in Fig. 3. Two of these rings are required with each of the waterwheels. The defective edges of these castings were rebuilt by welding with a cast-iron welding rod after proper preheating. The welds were machined after completion, and when ready for reinstallation the rings appeared as shown in Fig. 4. Welding of two of the wheels proved so successful that all the waterwheels at the Bulls Bridge plant, together with their housings, have been or are being rehabilitated by oxyacetylene welding. The cost of these repairs will be less than $100 per wheel.



Figs. 1 to 4—Turbine runner and housing castings before and after welding.

Underfeed stokers can be forced up to 300 per cent of rating, which rate can be maintained continuously, and burn from 60 to 65 lb. of coal per square foot of grate surface. As to the stoker's efficiency in general, the best is obtained when the boiler is operated at not less than 100 per cent of rating.

The Absorption Refrigerating System

By H. J. MACINTIRE

ENGINEERS often express wonderment at the apparent unpopularity of the absorption refrigerating machine. As it was almost the first form of machine that was successful in the production of mechanical refrigeration and has been economical in operation, one might rightly wonder why the change has come about.

First, it should be said that the absorption machine is steam operated. Steam under but a few pounds gage is necessary, with 55 deg. F. cooling and condensing water, but the pressure required increases to from 25 to 40 lb. gage when the cooling water is at 90 deg. temperature. However, the chief claim advanced is that the absorption machine may operate economically at low evaporating pressures and temperatures, and therefore is distinctly a low-temperature machine. The truth of this is seen from the steam-consumption guarantee, with 70 deg. F. water, of 31 lb. of steam under 9 lb. gage pressure per ton of refrigeration per hour for an evaporating temperature of +5 deg. in the refrigerating coils to 34 lb. of steam at 11 lb. gage pressure for a boiling temperature of —25 deg. F., or —15 deg. brine. Neglecting the rise of the steam pressure, the increase in the steam consumption is only 9.7 per cent. With the usual simple ammonia compressor the horsepower would increase from about 1.38 at 175 lb. gage condenser pressure and +15 deg. F. brine to 1.76 for the same condenser pressure and —15 deg. brine, the capacity dropping off about 50 per cent.

Low Temperatures Permissible

The great increase in the volume of the gas to be handled occasioned by the use of low evaporating temperatures does not cause much difficulty with the use of aqua. In the case cited the volume of one pound of ammonia increases from 8.06 cu.ft. at 20 lb. gage to 18.0 cu.ft. at zero lb. gage, or an increase to 224 per cent of the original volume. Of course the pipe connections from the brine cooler to the absorber must be large enough so as not to cause appreciable pressure drop during the gas flow, but the absorber surface is only increased from about 21 sq.ft. to 24 sq.ft. of cooling surface per ton of refrigeration, using the atmospheric type of absorber and increasing the water rate from 3½ to 4.0 gal. per min. per ton. It can use exhaust steam or steam at 10 to 15 lb. pressure, and if such steam is available at a nominal expense, there is a great advantage in the absorption machine. Oil refineries, certain meat packers, hotels, and manufacturers who do not operate their prime movers condensing but use their exhaust for heating in the winter, may well use the absorption machine for refrigeration in the summer. It should be emphasized, however, that steam is necessary for the generator of the absorption system, and in these days of electrification this steam factor is important. The absorption machine is also bulky, expensive in first cost and, with 80 deg. F. condensing water, requires much more water than does the compression system.

Competition of Compression System

During the last five to ten years, however, the two-stage ammonia compression machine has been perfected. Now every large manufacturer of refrigerating compressors can supply two-stage compressors, and the advantages of such operation are clearly known. The result is that where low refrigerating temperatures are required, the stage compressor can be operated with two expansion valves and with a water-cooled gas intercooler between the two cylinders. This design seems to work out satisfactorily in the most severe cases of low-temperature refrigeration, and the absorption machine is left only the field where exhaust steam in sufficient quantities is available, making refrigeration somewhat of a byproduct.

The principle of the operation of the absorption machine is the ability of water to absorb large quantities of ammonia, concentrations varying from 15 to 35 per cent by weight being used. The absorption of ammonia gas into a solution increases as the pressure is raised and as the temperature is lowered. For example, a solution is saturated with gas at 100 lb. absolute and a temperature of 275.8 deg. F. with a 10 per cent solution and can absorb no more, but at 150 lb. absolute at 275.8 deg. it is saturated with a 16.2 per cent solution, or it would be saturated with a 10 per cent solution at 306 deg. F., the pressure being the same. This relation is shown in the table. Evidently, then, if warm condensing or cooling water only is supplied for use, it is necessary to use low concentrations of aqua in the

TABLE I—TEMPERATURES, PRESSURES AND CONCENTRATIONS FOR AQUA AMMONIA

Pressure on Aqua in Pounds per Square Inch Absolute

*	10	15	20	25	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
2	169.0	189.4	206.5	220.0	231.1	249.4	264.3	277.9	288.8	299.0	307.8	316.2	323.7	330.7								
4	161.0	180.8	197.5	210.5	221.9	240.3	255.0	267.7	278.9	288.6	297.3	305.6	313.4	320.3								
6	153.0	172.3	188.8	201.5	212.4	229.5	244.0	258.0	269.0	278.5	287.4	295.3	302.6	309.6	316.0	322.2						
8	143.5	164.2	180.1	193.1	203.7	221.4	236.0	248.2	259.0	268.5	277.3	285.1	292.5	299.6	305.8	311.6						
10	137.4	154.3	171.1	183.7	194.6	212.3	227.0	239.6	250.5	259.5	267.9	275.8	282.9	289.4	295.7	301.8	307.4	312.6				
12	129.0	147.8	163.1	175.1	185.5	203.3	217.2	229.2	240.0	249.4	258.1	265.6	272.7	279.7	285.6	291.5	297.0	302.2				
14	120.5	140.1	155.5	167.4	177.6	195.2	209.1	220.8	231.2	240.5	248.9	256.1	263.0	269.7	276.0	281.8	287.3	292.4	297.1	302.0		
16	113.0	133.0	147.4	159.3	169.4	187.1	200.5	212.0	222.2	231.6	239.9	247.3	254.0	260.4	266.4	272.2	277.5	282.8	287.3	292.0		
18	107.5	124.9	139.4	151.4	161.2	178.3	192.0	203.1	213.5	222.6	230.9	238.0	244.7	251.0	257.0	262.5	268.0	273.0	277.6	282.4	287.0	291.7
20	99.0	117.3	132.0	143.6	153.8	170.2	183.6	195.4	205.0	213.8	221.8	229.1	235.9	242.0	247.9	253.5	258.6	263.6	268.4	273.3	278.0	282.7
22	92.0	109.9	124.6	139.9	146.0	162.7	175.9	187.0	196.9	205.6	213.5	220.6	227.1	233.4	239.3	244.7	250.0	254.9	259.3	263.9	268.5	273.0
24	86.0	103.0	117.0	129.5	139.2	155.2	168.7	180.0	190.0	198.4	206.0	213.0	219.2	225.5	231.3	236.7	241.9	246.7	251.0	255.5	260.0	264.5
26	79.2	96.3	110.6	122.1	131.9	148.2	161.0	172.1	182.0	190.7	198.2	205.1	211.5	217.6	223.4	228.7	233.7	238.4	243.0	247.2	251.5	255.8
28	73.4	90.6	103.6	115.3	125.0	140.6	154.0	165.2	174.7	182.8	190.3	197.1	203.1	209.3	215.0	220.4	225.5	230.3	234.5	238.9	243.2	247.5
30	66.5	83.8	97.0	108.5	117.8	133.5	146.1	157.0	166.4	174.9	182.7	189.4	195.6	201.3	206.9	212.2	217.3	222.0	226.7	231.1	235.1	239.3
32	61.0	76.9	90.0	101.0	111.0	127.1	139.4	149.7	158.8	167.3	175.0	182.0	188.2	194.0	198.4	204.5	209.4	213.8	217.7	222.0	226.4	230.8
34	55.0	71.6	84.0	94.8	104.5	120.0	132.0	142.4	151.9	160.2	167.8	174.6	180.9	186.6	191.9	197.0	201.7	206.1	210.0	214.2	218.3	322.5
36	49.0	65.5	78.5	88.8	98.1	113.5	125.8	136.0	145.3	153.3	160.7	167.3	173.5	179.3	184.7	189.7	194.5	199.1	202.9	206.8	210.6	214.4
38	43.0	60.0	72.5	83.2	91.8	106.8	119.4	130.0	138.7	146.7	153.8	160.3	166.4	172.2	177.5	182.5	187.3	191.7	195.6	199.3	203.0	206.9
40	37.0	53.8	66.0	77.3	86.0	101.0	112.9	123.4	132.3	140.0	147.0	153.4	159.4	165.0	170.5	175.5	180.1	184.6	188.9	192.8	196.5	200.1
42	31.6	48.7	61.0	71.5	79.4	94.0	106.3	116.4	124.9	132.5	139.8	146.4	152.7	158.2	163.5	168.5	173.3	177.7	181.4	185.3	189.2	193.0
44	27.5	43.2	55.3	65.3	73.6	87.8	100.1	110.3	118.8	126.3	133.4	139.9	146.0	151.5	156.7	161.6	166.3	170.8	174.3	178.2	182.0	185.0
46	21.2	37.6	49.7	59.6	68.1	82.0	94.0	102.2	112.8	120.1	126.9	133.4	139.5	145.0	150.2	155.0	159.4	163.8	167.5	171.3	175.2	179.9
48	16.0	32.0	44.4	54.2	62.7	76.7	88.3	98.5	106.7	114.0	120.6	127.0	132.9	138.4	143.7	148.6	153.3	157.5	161.2	164.9	168.6	172.5
50	11.0	26.8	38.9	48.4	56.8	70.9	82.6	92.6	100.8	108.3	114.9	121.0	126.9	132.4	137.2	142.0	146.4	150.7	154.9	158.7	162.4	166.0

* Concentrations

absorber, and in consequence also in the generator. In order to drive this ammonia out of solution in the generator, a higher steam pressure must be carried. The amount and the temperature of the condensing water play a double part in this machine, as the steam pressure carried in the generator as well as the condenser pressure is affected.

Refrigeration Calculations

The cooling water may be used in series, first in the condenser and then in the absorber, weak aqua cooler and rectifier, provided cold water is used, but otherwise the absorber must have the coldest water direct. The point here is that the absorber has a definite amount of heat to be removed, dependent on the operating conditions. Likewise a set of conditions of operation in the generator means a definite amount of heat to be absorbed in the generator from the steam. To bring these points out a problem will be solved.

Problem: Concentrations of 23 and 28 per cent are carried in the absorber, and the weak aqua enters the absorber at 120 deg. F. and the strong aqua leaves the absorber at 90 deg. F. Find the heat removed per pound of ammonia gas entering the absorber and the amount of cooling water required if the water is heated 10 deg. F. The pressure in the absorber at 28 per cent concentration and 90 deg. temperature is 14.5 lb. per sq.in. The heat removed by the cooling water can be found best (and most conveniently) by dividing up the process into three parts, although the action is not broken up in reality. We can say that the gas entering the absorber must first be condensed (at the pressure of the absorber), and as a liquid it will be dissolved in the weak aqua coming from the bottom part of the generator. The action of dissolving evolves heat called the "heat of the solution," which must be removed by the cooling water. Finally, the strong aqua leaves the absorber at a certain temperature, but usually colder than the weak aqua entering the absorber. The weak aqua therefore must be cooled an amount depending on this difference of temperature.

Heat Taken up in Absorber

The absorber action involves, then the removal of: (1) The latent heat of vaporization (or rather the difference between the total heat in the gas and the heat in the liquid at the absorber pressure); (2) the heat of solution; (3) the cooling of the weak aqua (in the problem from 120 to 90 deg. F.).

One has to imagine that the first action, liquefaction, takes place at the low temperature corresponding to the pressure and that the liquid ammonia immediately rises in temperature to that of the strong aqua being produced. This action is practically instantaneous. The heat removed per pound would then be the heat in one pound of saturated ammonia *minus* the heat content of the liquid as given in the ammonia tables. The heat of solution is best given by the Mollier values and is represented by the formula

$$Q_{\text{in B.t.u.}} = 345\,(1 - x) - 400x^2$$

where x is the *average* of the strong and the weak concentrations.

Finally, in the third item the specific heat has to be computed and is given here as the sum of the products of the relative specific heats and the weights of the water and the ammonia. The number of pounds of weak aqua circulated depends on the concentration of the weak and the strong, as of course the difference

TABLE II—HEAT REMOVED IN ABSORBER FOR DIFFERENT VALUES OF STRONG AND WEAK AQUA

Temperature and Concentration of Strong Aqua — 25 Per Cent

Per Cent Weak Aqua		60 deg. F. 80	60 deg. F. 100	60 deg. F. 120	80 deg. F. 100	80 deg. F. 120	80 deg. F. 140	100 deg. F. 120	100 deg. F. 140	100 deg. F. 160
		Temperature Weak Aqua								
10	G	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	H	853	954	1,056	838	939	1,041	821	924	1,026
15	G	8½	8½	8½	8½	8½	8½	8½	8½	8½
	H	892	1,046	1,200	877	1,032	1,186	862	1,016	1,173
20	G	16	16	16	16	16	16	16	16	16
	H	1,035	1,344	1,656	1,021	1,332	1,644	1,006	1,318	1,636

Temperature and Concentration of Strong Aqua — 30 Per Cent

Per Cent Weak Aqua		60 deg. F. 80	60 deg. F. 100	60 deg. F. 120	80 deg. F. 100	80 deg. F. 120	80 deg. F. 140	100 deg. F. 120	100 deg. F. 140	100 deg. F. 160
		Temperature Weak Aqua								
15	G	5⅔	5⅔	5⅔	5⅔	5⅔	5⅔	5⅔	5⅔	5⅔
	H	828	923	1,019	812	908	1,004	795	891	989
20	G	8	8	8	8	8	8	8	8	8
	H	862	1,007	1,153	848	993	1,139	831	976	1,125
25	G	15	15	15	15	15	15	15	15	15
	H	995	1,285	1,579	980	1,274	1,568	964	1,258	1,559

Temperature and Concentration of Strong Aqua — 35 Per Cent

Per Cent Weak Aqua		60 deg. F. 80	60 deg. F. 100	60 deg. F. 120	80 deg. F. 100	80 deg. F. 120	80 deg. F. 140	100 deg. F. 120	100 deg. F. 140	100 deg. F. 160
		Temperature Weak Aqua								
20	G	5⅓	5⅓	5⅓	5⅓	5⅓	5⅓	5⅓	5⅓	5⅓
	H	799	889	979	783	873	963	766	856	948
25	G	7½	7½	7½	7½	7½	7½	7½	7½	7½
	H	830	966	1,102	814	950	1,087	798	934	1,074
30	G	14	14	14	14	14	14	14	14	14
	H	952	1,224	1,499	937	1,211	1,487	921	1,197	1,480

Temperature and Concentration of Strong Aqua — 40 Per Cent

Per Cent Weak Aqua		60 deg. F. 80	60 deg. F. 100	60 deg. F. 120	80 deg. F. 100	80 deg. F. 120	80 deg. F. 140	100 deg. F. 120	100 deg. F. 140	100 deg. F. 160
		Temperature Weak Aqua								
25	G	5	5	5	5	5	5	5	5	5
	H	769	852	936	752	836	920	735	819	905
30	G	7	7	7	7	7	7	7	7	7
	H	796	922	1,047	779	906	1,033	762	890	1,020
35	G	13	13	13	13	13	13	13	13	13
	H	907	1,160	1,416	891	1,147	1,404	876	1,132	1,397

of the two concentrations determines the amount of ammonia absorbed by the weak aqua in the absorber and given up by each pound of the strong aqua in the generator. The number of pounds of weak aqua that must be circulated in order to absorb one pound of anhydrous ammonia is given by

$$G = \frac{1 - x_2}{x_2 - x_1} - 1$$

where x_2 is the concentration of the strong, and x_1 is the concentration of the weak, or

$$\frac{1.0 - 0.23}{0.28 - 0.23} - 1 = 14.4 \text{ lb. weak aqua per lb. of ammonia absorbed.}$$

The total heat removed per pound of ammonia gas entering the absorber is then:

1. $H_{14.8\ lb.} - h_{90\ deg.} = 601.8 - 143.5 = 458.3$ B.t.u.
2. Heat of solution $= 345(1.0 - 0.255) - 400 \times 0.255^2 = 231.0$ B.t.u.
3. To cool the weak aqua = weight × spec. heat × degrees of cooling = $14.4 \times 1.042 \times (120 - 90) = 450.2$ B.t.u.

Total 1,139.5 B.t.u.

If colder water had been used, say, to get the strong aqua to 70 deg. with the same pressure (14.4 lb.), then a 34 per cent concentration could have been carried and only 6 lb. of weak aqua would have to enter the absorber in order to absorb one pound of ammonia gas. The heat removed under these conditions would be considerably less, for

1. Would be the same as before ..... 458.3 B.t.u.
2. The heat of solution would become .... 215.0 B.t.u.
3. This item would be $6.0 \times 1.042 \times (120 - 90) =$ ..... 187.5 B.t.u.

Total 860.8 B.t.u.

The generator (using 75 deg. F. condensing water) will have a pressure of about 165 lb. gage, for which steam at 27 lb. gage will be necessary. Assume that the strong aqua enters the generator at 200 deg. F. Then the heat required per pound of ammonia condensed in the condenser will be

a. Heat of the solution (as before)..... 231.0 B.t.u.
b. Heat of vaporization ($H_{180\ lb.} - h_{200\ deg.}$) $= 632 - 387 = 245.0$ B.t.u.
c. Heat of superheat .....$742 - 632 = 110.0$ B.t.u.
d. Heat of aqua $15.4 \times 1.205 \times (260 - 200) = 1113.0$ B.t.u.

Total 1699.0 B.t.u.

The action of the generator is similar, but reversed, to that of the absorber. The 14.4 lb. of weak aqua now becomes 14.4 + 1.0 = 15.4 lb. of strong aqua. It invariably comes into the generator at a temperature lower than the aqua in the process of boiling and therefore must be heated an amount equal to this difference of temperature. The 1,699 B.t.u. must be supplied by the steam to drive one pound of ammonia gas out of the solution in the generator. The action of the steam in the steam coils of the generator would be, first to heat the strong aqua to the temperature of the generator, then break up the bond between the ammonia and the water (or weak aqua) and finally vaporize the liquid anhydrous ammonia at the generator pressure, which corresponds to a temperature much lower than that in the generator. In this last case the *net* heat supplied must be the difference between the heat content of the vapor at the generator pressure and of the liquid at the aqua temperature. Finally, the vapor driven off goes out at a temperature of the aqua in the generator (260 deg. in the problem), whereas the temperature of saturation for 180 lb. absolute is 89.8 deg. F.; therefore there is 260.0 — 89.8 = 170.2 deg. F. of superheat in the exit gases.

If the colder water had been used in the absorber, which would have permitted the use of a 34 per cent concentration, then the heat removed would be the same for all terms except 1 and 3.

1. The heat of solution..... 215.0 B.t.u.
2. Heat of vaporization..... 245.0 B.t.u.
3. Heat of superheat..... 110.0 B.t.u.
4. The heating of the aqua $6.0 \times 1.205 \times (260 - 200) = 434.0$ B.t.u.

Total (for these conditions) 1004.0 B.t.u.

In addition some 15 per cent of water vapor is boiled out, which is again condensed in the rectifier. This requires $0.15 \times 933.2 = 140.0$ B.t.u., making a total of 1,144 B.t.u. in the second case as compared with 1,699 + 140 = 1,839 B.t.u. in the first case.

The steam required in the two cases would be approximately (for 14.5 lb. boiling pressure of the ammonia)

$$\frac{1,145}{934.1} \times 60 = 73.6 \text{ lb. of steam per hour if 1 lb. of ammonia is condensed per minute.}$$

$$= 73.6 \div 2.343 = 31.4 \text{ lb. steam per ton per hour.}$$

$$\frac{1,840}{934.1} \times 60 = 118.2 \text{ lb. of steam per hour if 1 lb. of ammonia is condensed per minute.}$$

$$= 118.2 \div 2.343 = 50.5 \text{ lb. steam per ton per hour.}$$

The heat absorbed in the absorber is shown in Table II. The water required in the absorber in the two cases would be 114 and 86 lb. per pound of ammonia absorbed in the absorber, or 5.82 and 4.40 gal. of water per ton of refrigeration per minute respectively, G in the table indicating the gallons per ton and H the heat removed in the absorber.

It will be seen that care in the operation has considerable to do with the action and economy of the generator.

Low-Temperature Coke

Much has been said in favor of low-temperature coke as a solution of the smoke problem, and if all small consumers would adopt this fuel, such claims would probably hold good, states J. D. Davis, fuels chemist, Bureau of Mines, Department of the Interior, and V. Frank Parry, research fellow, Carnegie Institute of Technology, in Bulletin 8, Coal Mining Investigations, just published by the Carnegie Institute of Technology.

In the interest of smoke abatement it is not necessary for large consumers to use coke, excepting perhaps the railroads, and further, it may be questioned on good grounds whether this course will ever be economically feasible. Large power-plants can and do burn bituminous coal with little smoke and with high efficiency; it is only the small power user who does not realize that smoke means waste, also the domestic consumer, that really require a smokeless fuel. Here indeed would seem to lie the legitimate field for low-temperature coke; but it must have something to recommend it besides its smokeless qualities. It must command a higher price than competing fuels, and to this end it must be more economical, or more convenient to use, or both.

Some High Points on Modern Transformers

A FEW examples of recently built large-capacity transformers, together with a short description of their salient features, which will illustrate some of the accomplishments in modern construction.

By ARTHUR PALME
Transformer Engineer, General Electric Company

A NUMBER of 22,000-kva. single-phase transformers have been built and represent, on account of the low frequency (25 cycles), the physically largest single-phase units so far constructed. They transform from 39,500 to 12,000 volts. Three of these units form one Y-connected three-phase group of 66,000 kva. and are insulated for 68,500 volts. Under full load they operate at an efficiency of 99 per cent. The iron core, Fig. 1, weighs 35 tons, and the complete unit weight is 80 tons, including 5,700 gal. or 20 tons, of oil. Fig. 3 shows the coils and core assembled ready to be placed in the tank. Including the high-voltage bushings the transformers stand 19 ft. high. Each of these machines requires 68 gal. of cooling water per minute to keep its temperature within permissible limits.

Several 20,000-kva. single-phase high-voltage transformers are installed on the Pacific Coast, and step up from 72,000 to 220,000 volts on a 50-cycle system. These are the highest transmission voltage machines ever built. As these single-phase units are combined in three phase banks, operating with grounded neutral, only one of the bushings on the cover is designed for 220,000 volts. The other end of the winding terminates in a small insulated stud on the cover, to which is connected a current transformer to measure the ground current. An efficiency of 98½ per cent has been reached at full load. The machines weigh each 79 tons, including 33 tons of oil and require 94 gal. per min. of cooling water. The over-all height of these transformers is 24 ft., of which the high-voltage bushing takes up 9 ft. The cores and coils are shown assembled in Fig. 6 and a complete unit in Fig. 2.

Unusual Arrangement of Radiators

Two 10,400-kva. single-phase transformers were built which are interesting because of the unusual arrangement of the radiators for cooling the oil, Fig. 4. A self-cooled transformer was desired, but there was not room inside the plant to accommodate the necessary 18 radiators arranged in the usual way around the tank. Consequently, the radiators were banked into a nest of 18, arranged in two rows of 9 each on either side of a large top and bottom header, as shown to the right in Fig. 4, which is a view looking down on top of the unit. The top of the oval tank can be seen on the left. The nest of cooling radiators was mounted outside the power-house wall and connected to the top and bottom of the transformer tank by means of the two headers. Transforming from 13,800 to 27,600 volts, the machines operate as auto-transformers, which accounts for the exceptionally high efficiency of 99½ per cent. The output of the machines as auto-transformers is 20,834 kva., and they weigh each 40 tons, oil included.

The 15,000-kva. three-phase transformer shown in Fig. 5 is one of the largest self-cooled machines in existence. To dissipate the losses of one unit, amounting to about 155 kva., there are required 20 radiators, attached symmetrically around the oval steel tank, giving a total radiating surface of about 6,250 sq.ft. These transformers are equipped with three independent windings for 132,000, 72,000 and 12,470 volts, taps being provided in each one of these. The neutral Y-point on the high voltage is grounded. Including oil, 58,000 lb., the complete transformer weighs 168,000 lb. Fig. 5 shows a view of one of these transformers looking down from above. The arrangement of the radiators around the oval tank can be clearly seen. The conservator tank in which the expansion and contraction of the oil is taken up, is at the top of the picture.

The transformer, Fig. 7, has a three-phase rating of 18,750 kva. 88,000 to 6,600 volts, 60 cycles. It is capable of standing a 25 per cent overload for 24 hours, or nearly 24,000 kva. This transformer is one of the largest three-phase units in America. Its efficiency is 98.9 per cent and it weighs complete 74 tons, 28 tons of which is oil, and requires 70 gal. of water per minute for cooling purposes.

Three-Phase Transformers Built with Double Rating

Some 10,000- to 20,000-kva. three-phase transformers have been built. These machines are mentioned because they are representative of a special class, the so-called "dual-method-cooled" type. A station required a transformer with a capacity of 20,000 kva., and because there was an ample water supply, a water-cooled machine was chosen. This meant that the transformer depended upon an uninterrupted supply of cooling water. If this should fail for any reason, the transformer would have to be taken off the line.

The design of a straight water-cooled transformer depends entirely upon the cooling action of the water circulating through its cooling coils, to dispose of the heat losses. The surface of the tank of such a machine is as small as possible and therefore not capable of radiating any appreciable amount of heat. If, therefore, the cooling-water supply is not absolutely assured, it is wise to provide a water-cooled transformer with a tank that can take care of at least a part of the power output during such times as the water may fail. Usually, enough tank surface is provided to give one-half of the normal rating without water cooling.

These transformers, taken as an illustration of this type, are normally rated at 20,000 kva. and require 39 gal. of cooling water per minute. The tanks are equipped with eleven radiators each, providing a total surface of about 3,755 sq.ft., which is sufficient to dispose of the losses at 10,000-kva. load. The core and coils of these transformers weigh 26 tons and are submerged in 23 tons of oil. They step up from 12,600 to 48,400 volts with an efficiency of 99.05 per cent at full 20,000-kva. load.

It may be stated that there are several 60,000-kva. 50-cycle 110,000-volt three-phase water-cooled transformers, built about six years ago, in successful operation in Europe.

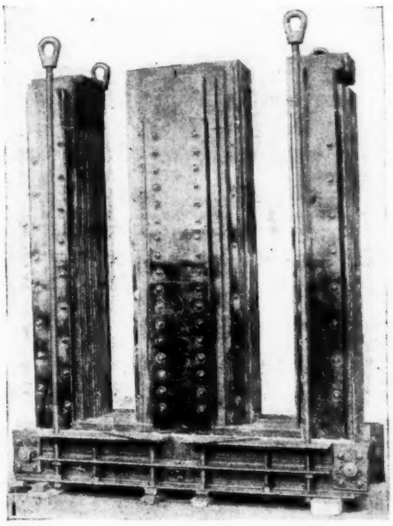


Fig. 1—Core for transformer, Fig. 3

Note heavy coil-supporting structure at bottom of core.

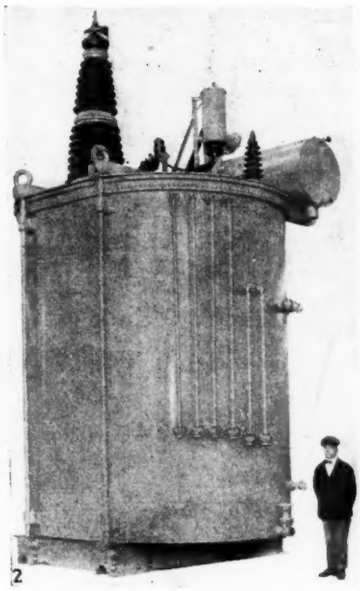


Fig. 2—Exterior of 50-cycle 20,000-kva. 72,000- to 220,000-volt transformer

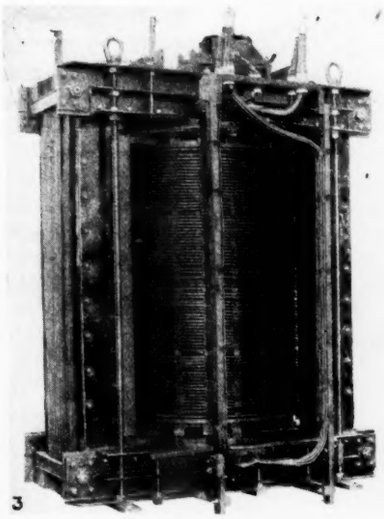
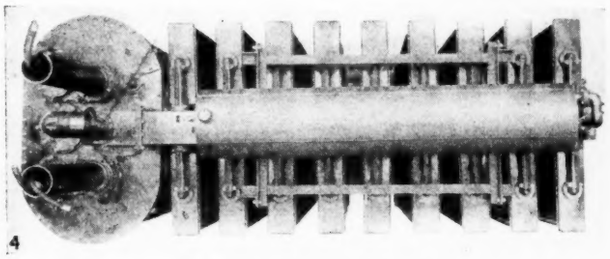


Fig. 3 — Assembled 25-cycle 22,000-kva. transformer ready to be placed in tank

Fig. 4—Single-phase 10,400-kva. transformer

Tank is on the left, radiators for cooling the oil on the right. View taken from above to show arrangement of radiators.



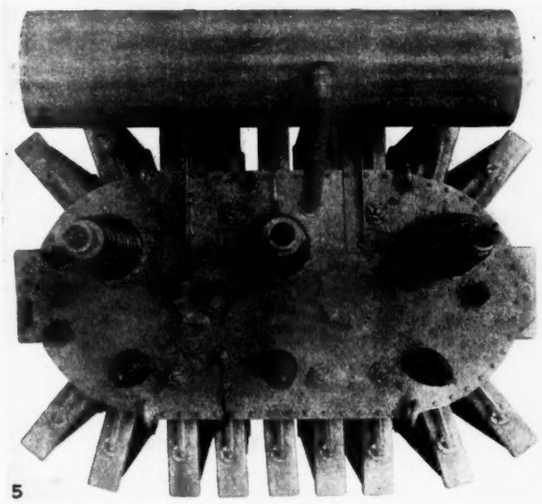


Fig. 5—Self-cooled three-phase 15,000-kva. transformer

Plan view taken to show arrangement of radiators around oval tank.

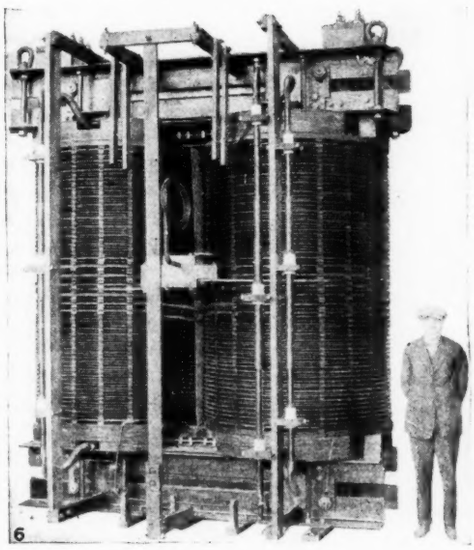


Fig. 6—Coils and core for single-phase transformer, Fig. 2

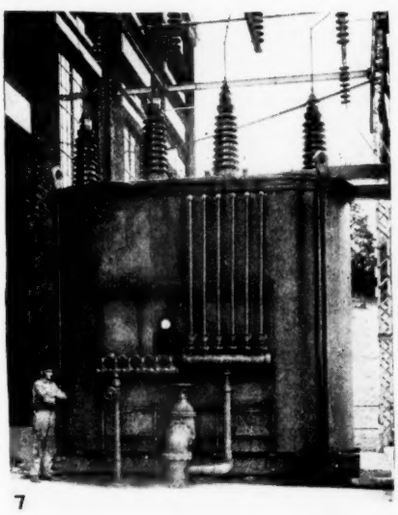


Fig. 7—Exterior view of 60-cycle 18,750-kva. transformer

Periodic Power-Plant Inspection

IN ORDER to minimize interruptions to service, accidents that might result in personal or property damage on account of defective equipment, and to secure maximum practicable efficiency in operation, it is desirable that periodic inspections be made at regular intervals of all power-station apparatus and equipment. In this connection the following partial list of general instructions issued by the Federal Light & Traction Co., New York City, to managers of their subsidiary companies may be of interest to readers of *Power*.

Once each year, preferably in the fall, the local manager shall call for following inspection report of all power-station apparatus, covering inspection of such equipment immediately prior to date of report or some time during the previous twelve months.

Turbo-Generator Units

a. Open up and examine blading, nozzles, shaft packing, glands, etc., for wear, clearance and scale.

b. Check levels and alignment.

c. Examine valve gear and other attachments for adjustment and wear.

d. Condition of foundation.

e. Check speed-limit device by overspeeding and recording tripping speed.

f. Wear on main bearings.

g. Scale or other foreign substance on cooling-water surface of bearing shells and oil-cooling piping, etc.

h. Condition of lubricating oil at the time of inspection.

i. Examine oil reservoir and piping for sludge and other deposits.

j. Cleanliness of windings and air passages, noting whether there are any signs of excessive heating of the coils and insulation.

k. Condition of the terminal connections, with special reference to any signs of heating.

Condensers

a. Physical condition of tubes and cleanliness of surfaces.

b. Tube packing.

c. Mechanical vacuum breaking apparatus, including inspection of actuating float.

d. Internal examination of water-sealed relief valves.

e. Careful inspection of all pipe, joints, valves, packing, etc., under vacuum for air leaks.

Boilers, Stokers and Furnaces

a. Check up steam pressure for which boiler was originally designed with pressure being allowed as per current boiler inspection reports, having in mind the fact that it is desirable to keep up allowable pressure to the highest practicable limit.

b. Examine interior of boiler surfaces for scale, corrosion, pitting, cracks, etc., and exterior surfaces for accumulations of soot and slag.

c. Examine blowoffs, water columns, nipples and connections to boiler drums or shells.

d. Condition of boiler setting, interior and exterior, with particular reference to settling, bulging, cracks, broken out patches of lining, air peaks, etc. This inspection also includes the top covering as well as the walls. Also insulating material on exposed boiler surface.

e. Tightness of dampers, condition of gear and degree of ease with which they operate. This will involve a careful examination from boiler side of damper.

f. Condition of breeching, also covering if insulated.

g. Examine fusible plugs, scraping both ends and renewing if necessary.

h. Condition of stack, with statement as to when painted last if steel. This examination should include inspection of any guys and anchors.

Reciprocating Engine Generator Units

a. Alignment and tightness on foundation. Examine foundation for cracks, oil penetration, settling and movement.

b. Internal examination, noting wear, evidence of scoring, measuring and recording wear in horizontal and vertical dimensions at each end of cylinder and midstroke. Record wear as thousandths of an inch greater than diameter at head end.

c. Examine valves, ports and seats for scoring and wear.

d. Examine piston and piston rod carefully for wear and condition of rings. Test piston for solidity.

e. Examine valve gear for wear and adjustment.

f. Examine shaft, crankpin, crosshead pin, boxes, wedges, bearings, bolts, etc., for wear and adjustment.

g. Inspect carefully entire system of lubrication, both engines and generators, including character and condition of lubricating oil as found in service at the time.

h. Condition and cleanliness of windings and air-gap clearance between stator and rotor. Examine carefully for signs of excessive heating which has caused deterioration of the insulation.

Feed-Water Heaters

a. Open Type—Open up and inspect for accumulation of scale. Ascertain condition of trays, float, etc., and see that all trays for which the heater was originally designed are in place. Examine oil separator and its trap or U-tube overflow; be sure that it is in working order.

b. Be sure and see that makeup inlet float is set for low enough level in hot-water storage space to allow for "come and go" or variations in rate at which water is drawn from heater at which condensate enters. This point is exceedingly important in order to keep waste through heater overflow down to a minimum.

c. Examine and test relief valve and be sure that same is set properly and adjusted for a lower back pressure than any other relief valves which may exist on exhaust steam system. In this connection, be sure to see that a small-sized atmospheric vent-pipe outlet from top of heater is open at all times to prevent accumulations of air in heater steam space and thus reduce its capacity.

d. Closed Type—Examine for accumulations of scale and oil on tube surfaces and see that air and condensate are being scavenged properly from steam space.

Water Softeners and Tanks

a. A thorough and systematic inspection of softeners and tanks internally and externally for accumulations of scale and other foreign deposits, condition of

paint, evidences of serious corrosion, rot, etc. See that all floats and other devices under permanent adjustment are properly set.

b. Examine thoroughly interior of any filters in connection with water treating and purification, with special reference to cleanliness and condition of filter bed, graduation of filtering material and quantity of filtering material remaining.

Cooling-Water Facilities

a. Cooling towers should be inspected carefully for rotten and defective timbers, air and water leaks in sheathing, settling, deteriorated hardware, uniformity of water distribution, short-circuiting of air currents, etc. Basins should be cleaned thoroughly and examined for cracks.

b. Spray pond systems should be examined for clogging of nozzles, condition of piping, uniformity of pressure over entire system, etc. Basin should be cleaned and examined for cracks.

c. Circulating water piping should be inspected for tightness of joints, and explored where possible for accumulations of foreign substance in the pockets.

d. Traveling screens, stationary screens, trash racks, and intakes. General physical and mechanical conditions, etc.

Auxiliaries

a. Reciprocating Pumps—Examination of interiors of cylinders and steam chests, valve chambers, pistons, rods, plungers, liners, glands, valves, springs, etc., for wear, condition and kind of packing. Test for leakage of steam past piston. See that valves are set properly or "squared up."

b. Centrifugal Pumps—Examine impeller, wearing rings, diffusion vanes, bearings, etc., for erosion and wear. Condition and kind of shaft packing with number of rings in place. Condition and quality of oil as found.

c. Small Turbines—Examine internally for erosion and scale on blading, wear on nozzles, and clearance between nozzles and blading; lateral and vertical adjustment of runner. Test overspeed device; condition of throttle and all other parts subject to wear or change in adjustment. Include any reduction gear in this examination.

d. Exciter Generators—Cleanliness of windings, air-gap adjustment, commutator wear, condition of coils and insulation, brushes, brush-holders and connections. Bearings.

e. Fans—Condition of casing with particular reference to possible corrosion, bearings and cooling system, if any. Examine paddles, blades or vanes, and spider for signs of erosion or corrosion and accumulations of dirt. This is particularly important for induced-draft fan equipment.

f. Pump Governor and Feed-Water Regulators—See that these are in first-class working order and properly adjusted.

g. Fuel and Ash-Handling System—Complete and thorough inspection for wear on all parts, alignment, erosion, corrosion, and ability to go through another year in good serviceable fashion.

h. Motor Drives—Examine bearings for wear; see that air gap is uniform; check for alignment; inspect resistances and rheostats, slip rings, commutators, brushes, etc. Note carefully any signs of excessive heating and consequent deterioration of insulation.

Inspect carefully all parts of traveling cranes, hoists and elevators, and see that they are in first-class working condition, properly lubricated, well kept up and thoroughly safe. This includes complete inspection of motor drive.

Steam and Water Piping

a. Examine carefully for leaky joints, and if practicable look for any evidence of scale accumulation on the inside of feed lines.

b. Examine valves; see that they are in working order, no leaky stems, etc. *See that they close tight.*

c. Condition of pipe covering.

d. Examine all traps and be sure that they are operating properly. When gage glasses are broken, they should be replaced. Traps of bucket and float type must be opened and their interiors inspected. Be sure to see that no traps are blowing through.

Instruments and Switchboard Equipment

a. Observe condition and check accuracy of all measuring instruments, including flow meters, draft gages, CO_2 recorders, recording flue-gas thermometers, recording feed-water thermometers, boiler feed-water meter, condensate meters, condensate and circulating-water recording thermometers, recording blowoff-line thermometer, recording and indicating steam pressure and temperature gages, etc.

b. Inspect, test and adjust all relays, indicating, integrating and recording instruments on main switchboard and auxiliary panels.

c. Inspect carefully all switches and circuit breakers. Pay especial attention to condition of terminals, contacts, oil as to condition and quantity. Test mechanical and electrical operating devices and see that they work in proper conjunction with relays.

Other items of equipment not specifically mentioned herein, or parts not referred to for equipment enumerate shall likewise be inspected and reported upon as though specifically set forth herein.

Inspection Report

a. Report of this annual inspection to follow approximately the order herein prescribed, and to be tabulated on 8½x11-in. sheets.

b. In addition to descriptions covering condition as found there shall be a statement when defects are found covering condition as left, or concerning time and manner in which it is proposed to remedy the defects listed where such defects are sufficiently serious to merit early attention.

c. Inspection report shall be dated, bearing name of person making inspection, and signed by chief power station engineer.

Record of Maintenance

At each power plant shall be kept an apparatus maintenance record, made up on loose-leaf card system, and covering maintenance, repairs and replacements for all items of power station equipment. One or more separate cards should be provided for each piece of equipment, and entered thereon shall be the date, name of person making repairs, nature and extent of repairs, material and labor used in making the repair, cost of the repair and condition of equipment as left. A history will thus be provided for each and every item of equipment in the station, which will serve as a most useful and valuable future record.

Largest Two-Stroke-Cycle Diesel Built in America

Description of the Bethlehem 2,900-horsepower two-stroke-cycle Diesel engine; engine has no cylinder head; scavenging pumps are at side of frame, scavenging valves in the top of the cylinder.

ENGINEERS are so accustomed to learn of firms embarking upon the building of Diesel engines that such an event ordinarily causes little interest, for in the main these engines are more or less copies of European designs. However, the engineering public will have a keen interest in the Bethlehem Diesel, since it is of purely American origin, being designed by engineers of the Bethlehem Shipbuilding Corporation. Not being handicapped by European influences, it is not surprising that the engine possesses many features differing radically from those found in other designs. These departures, however, are based on sound engineering principles, as has been amply proved by operating results.

The Bethlehem engine has been given a thorough tryout in both land and marine service. Three years ago one was installed on the "Cubore," a 10,500-ton motorship belonging to a subsidiary of the Bethlehem Steel Co. As a result of the experience gained through this engine and through a second unit installed a year ago in the Bethlehem Lehigh plant, those minor changes always necessary in a new design were accomplished, and the builder is now prepared to supply engines in four, six and eight cylinders, ranging in capacity from 1,950 to 3,900 hp., for both stationary and marine service.

In constructing units of large power for marine service, it is necessary to reduce the power length and height as much as possible. Consequently, the two-stroke cycle has been adopted by several builders, a further inducement being the better maneuvering and more even torque of a two-stroke-cycle over a four-stroke-cycle engine of like number of cylinders. In land service room space is of importance, as is likewise the element of cost of construction. Both of these factors favor the two-stroke-cycle machine.

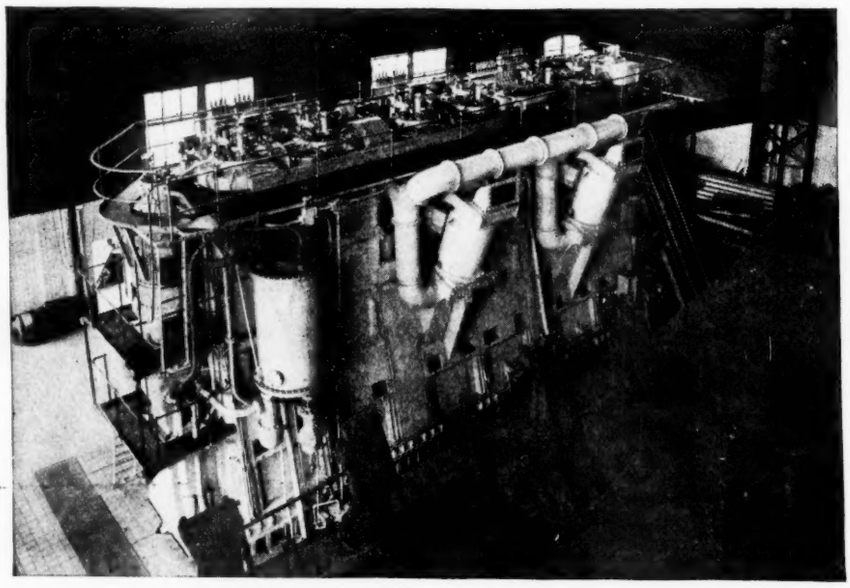


Fig. 2—Scavenging pump side of engine

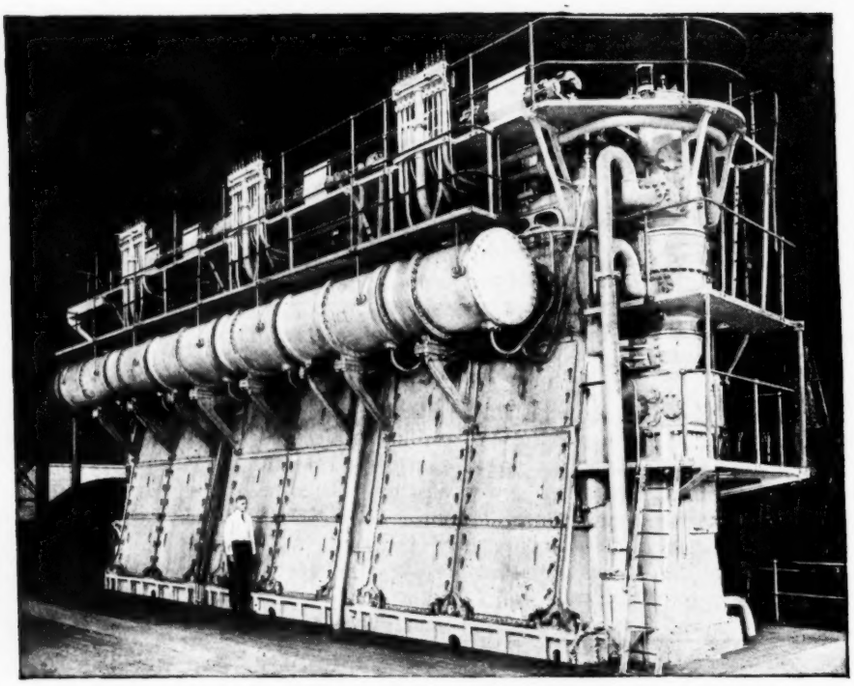


Fig. 1—Exhaust side of Bethlehem Diesel

The most striking feature of the Bethlehem two-stroke-cycle Diesel is the cylinder. In the usual oil engine the cylinder is made up of a barrel or jacket into which is placed a liner to receive the cylinder pressure and piston wear, the top of the cylinder being closed by a water-cooled head. This in a four-stroke-cycle engine contains openings for fuel, air starting, admission and exhaust valves, while in the usual two-stroke cycle the head contains fuel and two or more scavenging valves. The head is a

complicated casting and, being subjected to alternate heating and cooling, tends to fracture.

In the Bethlehem engine the designer has boldly abandoned the use of a cylinder head. As shown in Figs. 3 and 5, the liner is made in the form of a hollow mushroom. The body of the liner is brought to a smaller diameter at the top and is provided with a short outer skirt which acts as the top of the cooling-water jacket. The scavenging valve cage closes the small opening in the liner top, eliminating the costly cylinder head. It will be seen that the inner and outer walls are united only at the top of the cylinder, a point removed from the heat generated in the cylinder. Consequently, the difference between the expansion of the cold outer wall and the hot liner will not set up dangerous stresses. To form the cooling-water jacket, a light cast-iron sleeve is placed around the liner, the water circulating between. This sleeve contacts with

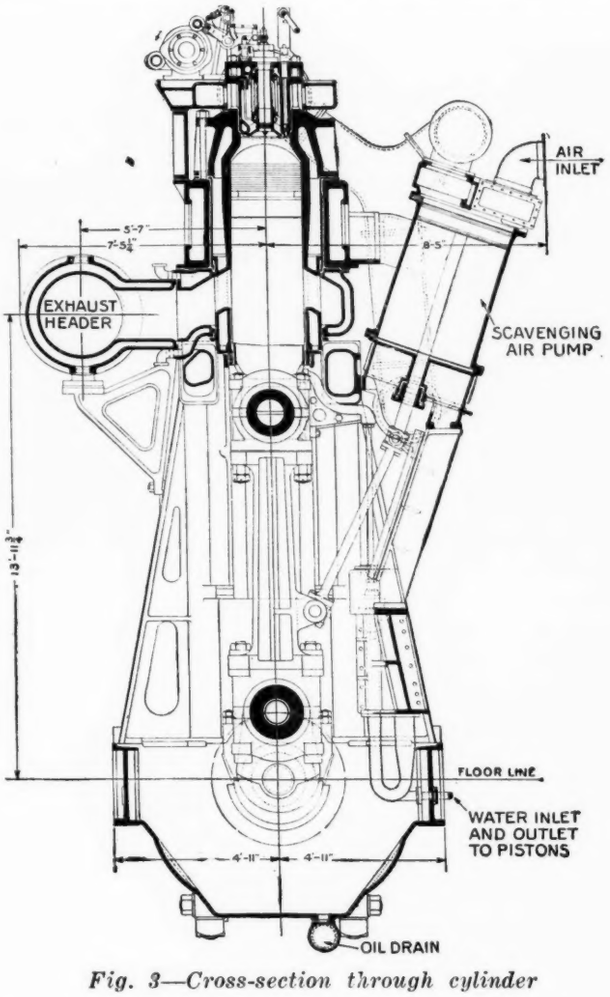


Fig. 3—Cross-section through cylinder

the liner mushroom skirt at the top, there being a watertight gasket used, and at the base slips over the exhaust port flange or shroud, being free to expand downward.

The exhaust ports are cast integrally with the liner, avoiding the usual joint between cylinder barrel and exhaust port casting. Two of these liners are set into a box, being held by studs. The cylinder pressure is transmitted through these studs to the cylinder box, each box resting on three A frames. Six tension rods transmit the stresses from the cylinder box to the bedplate close to the main bearings. To obviate all danger of bending of the frame, a series of through bolts pass horizontally through the frame adjacent to the vertical tension rods.

A scavenging pump ordinarily requires a floor space of greater area than does a working cylinder. This naturally increases the length of the engine and especially of the crankshaft. In the Bethlehem engine the scavenging pumps (there being two on the six-cylinder unit) are placed at an angle with the frame. Since

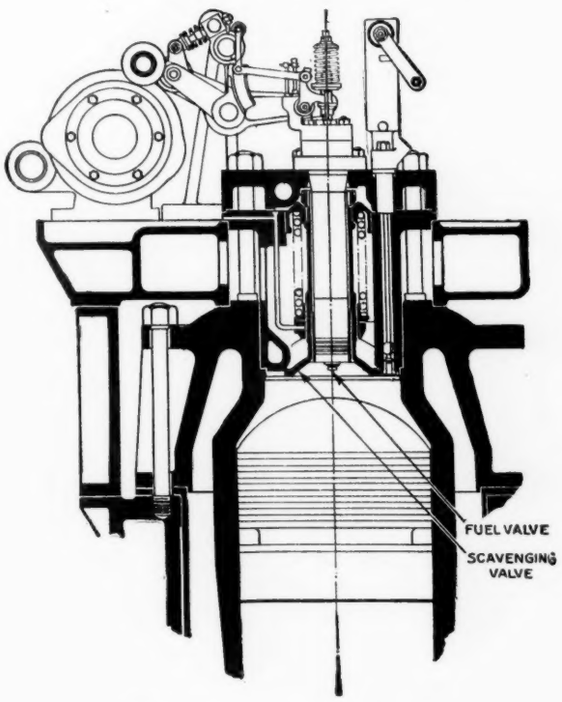


Fig. 4—Showing valve gear

the pump connecting rods are swung from the connecting rod of the working cylinder in line with the pump, there is a decrease in frame length and in the number of cranks ordinarily required. Since the load due to the scavenging pump is but 2 per cent of that due to the pressure within the power cylinder, this construction entails no increase in pin or bearing wear.

The scavenging air is led from the pump to the central scavenging valve in each cylinder top. This valve is of the mushroom type and is provided with a cage filling the open end of the cylinder. The valve has no stem, but is provided with a central sleeve through which passes the fuel or spray valve. The scavenging valves do not open until the piston has uncovered the exhaust ports, causing the cylinder pressure to drop below the scavenging air pressure. Although the valve cage is water cooled, the passing of scavenging air at each revolution would no doubt keep the valve and cage at a reasonable temperature.

The mushroom-type fuel valve is placed centrally in the scavenging valve and is actuated by a cam on the camshaft through a linkage shown in Fig. 4. To obtain the maximum economy at all loads, the spray valve has a variable lift under governor control.

The fuel-valve linkage includes a quadrant—in effect a Stephenson link. The link block is suspended by a link from the governor control shaft. The cam, by striking a roller, lifts the valve rocker arm whose

inner end is linked to the quadrant and so depresses the spray valve. It is obvious that the higher the link block is placed in the quadrant the smaller will be the duration and amount of the valve lift.

Injection air for the fuel spraying is supplied by a three-stage crosshead-type compressor driven off a crank that is bolted to the flange on the engine crankshaft.

The general design of the engine is based on the unit system, each consisting of two power cylinders,

Fig. 5—Cylinder liner

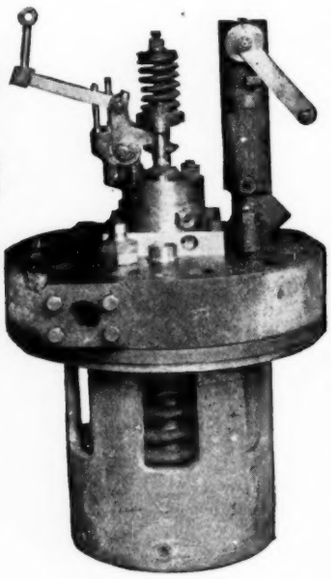


Fig. 6—Valve assembly

cylinder support, A frames, bedplate section and crankshaft section. This enables the engine to be built as a two-, four-, six- or eight-cylinder motor by combining these units. The crankshaft sections are interchangeable, each consisting of two cranks set 180 deg. apart, together with flanges on each end, forming an integral part of shaft. The timing of cranks needed for different combination of cylinders is obtained by the manner in which the shaft sections are bolted together. The construction of the section with the cranks opposite has two advantages. First, the inertia forces of the reciprocating parts attached to these cranks are, except for the angularity of the connecting rod, equal and opposite. The vertical planes in which these opposing and counterbalancing forces act are closer together than is possible with any other crank arrangement. The comparative closeness of these planes of action therefore keeps down to a minimum the tendency in a ship to produce periodic vibration. The "Cubore," having a six-cylinder engine, is for this reason remarkably free from such vibration. The second advantage in constructing a shaft section with two opposite cranks is very important from a practical point of view. It will be observed that in a six- or eight-cylinder engine a center section of crankshaft can be removed without disturbing either the other crankshaft sections or any part of the A frames.

A thirty-day continuous endurance run was made with the six-cylinder engine now being regularly used to generate alternating current for steel-mill service in the Bethlehem plant. The engine functioned perfectly, and at the end of the run was thoroughly inspected and found to be in excellent condition.

Steam Boilers

A Catechism by Warren Hilleary Served in Small Doses and Extending Over a Number of Issues

79. A mud drum is to be removed from a B. & W. boiler. Describe in successive steps just how you would proceed to do the work.

First remove the blowoff pipe connection. Next cut out the nipples from the headers, leaving the center one until the last. After cutting out the center one, remove as much of the brickwork from below as is necessary, drop the drum down until the tubes leave the headers. Take the drum out and place in a convenient position on a cribbing of 12x12-in. or equally substantial construction, built up about two feet in height. Cut out the nipples from the drum.

80. Describe by successive steps how you would proceed to retube the mud drum and put it back to position.

Clean to a bright smooth surface all tube holes in the bottoms of the headers and in the mud drum. Tube the mud drum, insert in position and block it to the right height. Lightly expand the top of the tube nearest the center. Next lightly expand each end tube. Next lightly expand all tubes, then proceed to roll all tubes to finish in the usual manner.

81. Why should inner straps of double-strap butt seams be wider than the outer straps?

This refers to triple-riveted seams, and as the outer row of rivets is pitched twice as wide as the other rows, and as the outer row engages only the wider strap, it is advisable to put the narrower strap outside, since this method makes calking more satisfactory. It is difficult to calk tightly over a space so wide as ordinarily exists between the outer row of rivets.

82. Should the inner strap of a double-strap butt seam extend to and touch the edge of the head flange or the edge of the sheet?

The ends of the inner strap should extend only beyond the last rivets through it far enough to provide proper strength in the ligament between the edge of the rivet hole and the end of the plate. In a properly designed seam the inner plate end will never touch the edge of the head flange or the sheet.

83. A horizontal tubular boiler 54 in. in diameter has a dome 30x30 in. This dome is riveted to the shell by a double row of rivets in the usual manner. The boiler furnishes steam for a plain slide-valve engine, running 220 r.p.m. The dome is found to vibrate considerably, and the selling agent of the boiler advises placing a rigid brace between the dome and the concrete wall of the room, one end of the brace to be secured to the boiler wall, the other end to a loop of strap iron fitted around the base of the dome, the brace extending in a right-angle direction from the boiler side wall. What, if anything, is wrong with this arrangement?

Vibration of the boiler should not be prevented by any means of bracing applied to the dome, for the reason that strains will be set up on the dome seams and other parts of the boiler in excess of the strains that the general construction is intended to resist. Assuming that the engine does not move on the foundations and that vibration is transmitted only from the engine to the boiler dome through the steam pipe or the steam in it, then the vibration can be stopped by increasing the steam-pipe area.

The Broadening Field of Service for Power-Plant Engineers

BY WALTER SLADER

A FEW months since, a brief editorial in *Power*, dealing with mechanical progress, stated: "The census of 1869 showed 0.6 horsepower available per workman, in factories of this country. The census just completed shows 3.27. This does not take into account the power consumed by the railways, mines, office buildings, hotels, electric lighting, automobiles, steamships, etc."

From 1907 to 1917 the output of central stations grew from less than six billion kilowatt hours to more than twenty-five billion.

In June, 1922, the public-service companies of this country alone are reported to have produced a daily average of 128,000,000 kw.-hr., which was the largest output ever reported up to that date. It must be borne in mind that this record figure was made in the face of, and in spite of, a considerable business depression, particularly affecting many classes of large power users. The growth of central-station building and output has been especially rapid within the last year. Of this total quantity of power furnished by public-service stations 58.6 per cent was fuel power, that is, power generated by the use of some sort of fuel.

THERE are many reasons justifying the conviction that present conditions call more plainly than ever before for the handling of power engineering matters by men trained for this work, who devote their time to nothing else. It seems reasonable to hope that a review of the power field may be of some general interest, especially to those who are in executive positions where these matters form a part, but often only a minor part, of many duties. An article to follow, "Highest Efficiency from Industrial Steam Plants" will develop the situation further.

George O. Smith, Director of the United States Geological Survey, in an interesting paper on "Industry's Supply of Energy," stated that the department's estimate of total power output for the United States during the year 1919 was 125,000,000,000 horsepower hours. Of this total more than 82 per cent was credited to steam, 15 per cent to water, and the remaining less than 3 per cent to internal-combustion engines. That is, 85 per cent of the whole power produced in this country during that year was through some application of heat energy.

Mr. Smith, in the article mentioned, gives further statistics regarding our country's ultimate resources as to power from water, coal and oil, which are so concise, clear and compelling in their way of setting forth the part which each may, and is likely to play, in our ultimate power development, that attention is here called to certain paragraphs. He says: "If we take 50,000,000 hp. as an average figure for the potential water power of the United States, without storage, we find that, if fully developed and if used at the average load factor of today, our rivers and streams would just about meet the country's present needs and would supply that amount of power for all time."

"Present power requirements of this country could be met with coal for 57,000 years. Adapting the best steam practice of today . . . and trying to carry the whole power load of the country with oil alone we find that the oil reserves of the United States . . . would last only nine (9) years and three (3) months."

Later opinions of other members of the same department, somewhat raise the estimate of total oil available, but a doubling or trebling of this estimate does not materially affect the ratio.

And further, Mr. Smith states: "In operation the water-power plant is a labor saver." The balance sheet of a large power company, operating both large steam and hydraulic plants, shows that "in terms of 1,000 kw. capacity it takes 13½ men to run the steam plant and the coal mines tributary to it . . . and one-sixth (⅙) of one man to run the corresponding units in the hydro-electric plant. The exact ratio is 84 to 1."

"Another comparison with coal is offered by the statement that in Mexico one man can produce and transport to market the oil equivalent of the coal that it would take ten men in the United States to mine."

These quotations show conclusively at least the following fundamental facts:

1. A very large further development of water-produced power is possible.

2. The amount and speed of this development will depend upon the extent to which it can be made economical as compared with power from heat sources.

3. The element of much less labor cost per unit production with water should be a permanent one, though perhaps not applying to the extent noted in the example quoted. This factor can be expected to remain of great importance as favoring further rapid water-power development.

4. A large and increasing quantity, though not an increasing percentage, of our total power output must come from coal.

5. While nothing is predetermined as to the advantage, either to the individual or society as a whole, of fuel oil for any specific case or time, it is certain that it can play only a relatively small part in our total or final power development.

That is, whether we look at our ultimate resources or at our present-day tendencies of development, we find that great further increases in power as produced from both water and coal are certain, and that not only has the field of the power specialist broadened largely in recent years, but there is every reason to expect that his work for the future should increase greatly both in volume and variety.

With the more complex conditions and requirements of today the importance of securing things necessary

to efficient operation, as well as a proper study and choice of refinements to assure best results in each individual case, makes necessary the work of men specially trained along this line, and furnishes the logical reason for the power-plant consulting engineer.

Many do not yet realize the importance to them and to their manufacturing properties, of the changes that recent improvements in use of water as a source of

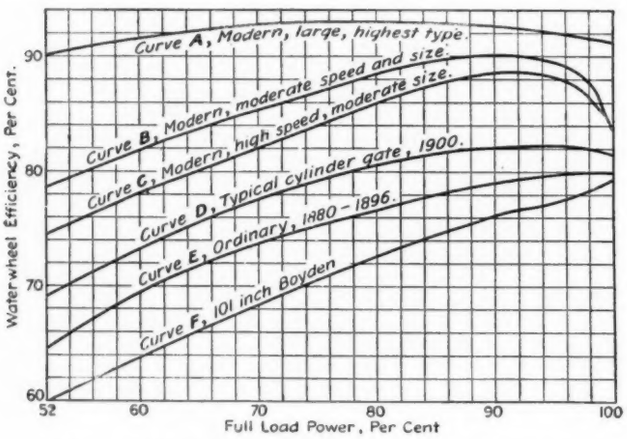


Fig. 1—Typical efficiencies of old and modern waterwheels

Many old wheels are so set that they cannot perform as well as when tested. This would tend to increase the gain possible with modern wheels.

power have brought. They are, broadly speaking, due to three causes: (1) Much more efficient waterwheels and methods of power transmission; (2) better use of total possible head, or waterfall; (3) better arrangements for water storage.

It Pays to Replace Old Waterwheels

Quite frequently, in a given case, only the first two items need consideration, and often the first alone is of such importance that the second can be to some extent neglected. That is, often it is very profitable to replace old waterwheels with new ones, making direct use of a considerable part of the old permanent development such as canal racks, penstocks and tailraces. When this can be done, those parts of the equipment that cost most are continued in use and the relatively least expensive parts changed. To what extent the three items just mentioned affect any particular old water-power plant can be told only by a careful study of that particular plant's conditions.

The accompanying group of curves, Fig. 1, show clearly the extent to which improvement in efficiency of waterwheels has increased their power output.

Curve *A* shows the efficiency at various percentages of normal full load of a very large waterwheel working at slightly over 300 ft. head, which forms one of the units some time ago installed in a modern hydro-electric station. Since that time still larger units have been installed which were designed to have practically similar efficiency curves. It should be particularly noted that this machine has an almost absolutely flat efficiency of 92 per cent to 93 per cent for all outputs between 65 per cent and 90 per cent of rated power. Actually, although the curve is not here shown for points above full load, the efficiency is 90 per cent or above for the entire range from 52 per cent to 107 per cent of load. This curve shows that for large units no great further gain in over-all wheel efficiency can be expected.

Curves *B* and *C*, Fig. 1, show efficiencies for modern "normal-speed" and "high-speed" waterwheels of moderate size and for heads of about 50 ft. Curve *D* shows the efficiency of a typical average cylinder gate wheel of the period about 1900. Curve *E* shows the test efficiency, when new, of a wheel that may be considered typical of many placed in service about 1896 or earlier. Curve *F* shows the efficiency of a 101-in. Boyden wheel. Not a few of these, which are now very old and operating at less efficient rates than here shown, are still in use.

A glance at the space distance between curves *B* or *C* and *D* or *E* will show part of the gain to be secured by substituting new for old wheels. This, however, often does not tell the whole story, for many of these old

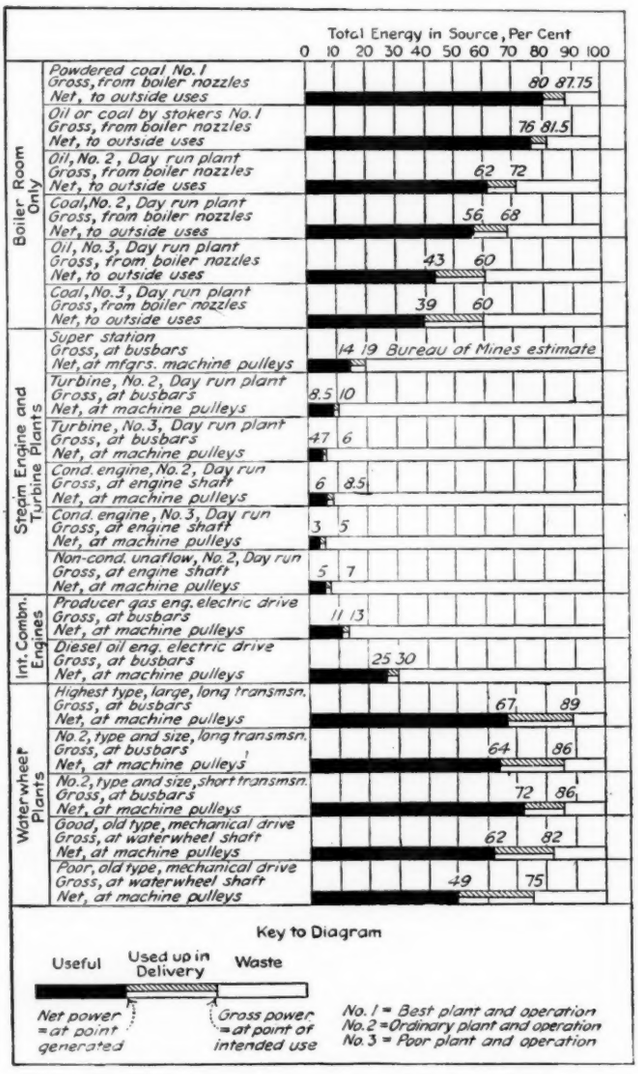

Total Energy in Source, Per Cent
0 10 20 30 40 50 60 70 80 90 100
Boiler Room Only
Powdered coal No. 1
Gross, from boiler nozzles 80 87.75
Net, to outside uses
Oil or coal by stokers No. 1
Gross, from boiler nozzles 76 81.5
Net, to outside uses
Oil, No. 2, Day run plant
Gross, from boiler nozzles 62 72
Net, to outside uses
Coal, No. 2, Day run plant
Gross, from boiler nozzles 56 68
Net, to outside uses
Oil, No. 3, Day run plant
Gross, from boiler nozzles 43 60
Net, to outside uses
Coal, No. 3, Day run plant
Gross, from boiler nozzles 39 60
Net, to outside uses
Steam Engine and Turbine Plants
Super station
Gross, at busbars 14 19 Bureau of Mines estimate
Net, at mfgrs. machine pulleys
Turbine, No. 2, Day run plant
Gross, at busbars 8.5 10
Net, at machine pulleys
Turbine, No. 3, Day run plant
Gross, at busbars 4.7 6
Net, at machine pulleys
Cond. engine, No. 2, Day run
Gross, at engine shaft 6 8.5
Net, at machine pulleys
Cond. engine, No. 3, Day run
Gross, at engine shaft 3 5
Net, at machine pulleys
Non-cond. unaflow, No. 2, Day run
Gross, at engine shaft 5 7
Net, at machine pulleys
Int. Combn. Engines
Producer gas eng. electric drive
Gross, at busbars 11 13
Net, at machine pulleys
Diesel oil eng. electric drive
Gross, at busbars 25 30
Net, at machine pulleys
Waterwheel Plants
Highest type, large, long transmsn.
Gross, at busbars 67 89
Net, at machine pulleys
No. 2, type and size, long transmsn.
Gross, at busbars 64 86
Net, at machine pulleys
No. 2, type and size, short transmsn.
Gross, at busbars 72 86
Net, at machine pulleys
Good, old type, mechanical drive
Gross, at waterwheel shaft 62 82
Net, at machine pulleys
Poor, old type, mechanical drive
Gross, at waterwheel shaft 49 75
Net, at machine pulleys
Key to Diagram
Useful
Used up in Delivery
Waste
Net power = at point generated
Gross power = at point of intended use
No. 1 = Best plant and operation
No. 2 = Ordinary plant and operation
No. 3 = Poor plant and operation

Fig. 2—Waterwheels are more efficient transformers of energy than steam plants

wheels were so set that in actual operation they could not perform as well as when tested.

Meanwhile the space between curves *A* and *B* is gradually being lessened by improved design and setting, resulting in greater efficiencies at part loads.

The United States Geological Survey's estimate of total power used in this country for 1919 apportioned

42 per cent to public utilities, 28 per cent to manufacturing industries, not including rented electric power, and 30 per cent to steam railroads.

A recent careful estimate by one of our great equipment producing organizations placed the coal consumption on main trunk lines using steam locomotives as 2.36 times that which would be required if operated with electric locomotives.

Such portions of heat energy as can be made useful for producing power are always secured by dropping the working medium down through a temperature range, from a higher to some lower heat level, and rejecting to waste, or to other use, all the energy it may contain at still lower temperature levels.

Our gains, in useful results secured from heat power equipment, have been made, and will in future be made:

1. By improving the efficiency of boilers, engines or turbines, thus converting into power more of the heat available, within a certain range.

2. By increasing the top level from which we start to use heat energy, or lowering the bottom level, that is, increasing the working range.

3. By finding new ways to make use of some portion of the heat energy, left at a lower level, which previously has been thrown away.

With any of the types of fuel burning the setting of the boiler and the design of furnace demand careful attention. The ability of almost all of our standard boilers to give best account of themselves as to output capacity, conversion of fuel into heat delivered to steam, and low upkeep cost of unit, is largely dependent upon the correct adaptation of these furnace features to conditions that they are to meet.

TABLE OF WORKING EFFICIENCIES OF ENGLISH PLANTS INCLUDING LANCASHIRE BOILERS, SUPERHEATERS AND ECONOMIZERS

	80 Plants Mechanically Fired		250 Plants (76 per cent Hand Firing and 24 per cent Mechanical Firing)	
	Number of Plants	Per Cent	Number of Plants	Per Cent
Over 80 per cent...	1	1.25	2	0.8
75-80 per cent...	2	2.50	9	3.6
70-75 per cent...	2	2.50	13	5.2
65-70 per cent...	17	21.25	30	12.0
60-65 per cent...	11	13.75	44	17.6
55-60 per cent...	16	20.00	62	24.8
50-55 per cent...	15	18.75	47	18.8
Less than 50 per-cent	16	20.00	43	17.2
	80	100.00	250	100.0
Average for all plants		59.0		60.0

Our largest and best boiler plants are operated, considering the boilers and furnaces alone, at a continuous efficiency of 80 per cent to 83 per cent or, allowing for all auxiliary uses and losses, about 75 per cent to 78 per cent.

Small Boiler Plants Inefficient

Our ordinary smaller boiler installations, such as are found in industrial plants, are working at continuous gross efficiencies, for operating periods, all the way from less than 50 per cent to nearly the values already mentioned, but with many of these, long banking periods play a much larger part than with the continuous operation station. A 24-hour plant or public-service station may reduce its banking charge to much less than one per cent of the total fuel used, while an 8-hour plant may use anywhere from 10 per cent to 30 per cent of the total fuel for stand-by or banking, thus making a great difference in the net efficiency attained.

Not a few industrial plants are doing no better than 50 per cent to 60 per cent, and relatively few are doing better than 70 per cent for operating periods with no allowance for boiler-room auxiliaries or waste steam.

David Brownlie, of Manchester, England, in a paper published under date of March, 1920, summarizes the results of a large number of careful tests and gives the net working efficiency for the plants, including Lancashire boilers, superheaters, and economizers — the usual English medium-sized plant equipment as per the accompanying table.

Average results with us may be slightly higher, but our own experience would indicate that for plants of an old design which are in good repair and which are handled by somewhat better than ordinary working forces, the value is 63 per cent to 68 per cent for operating periods, not considering auxiliaries.

When we pass beyond the boiler room, we find the large turbo-generator units in our best central stations making use of 76 to 80 per cent of the energy theoretically available at their throttles for a given heat range. Similar units of about 5,000 kw. size, such as are suitable for moderately large industrial plants have, in the multi-stage type, an efficiency of about 74 per cent, which for the simpler standard machines is reduced to 69 per cent.

For 1,000-kw. machines these values are about 65 per cent and 62 per cent, while for non-condensing back-pressure machines they are most often from 50 per cent to 60 per cent, depending upon machine design, number of stages and superheat available. Most of these turbines have fairly flat steam-rate curves over ordinary operating ranges; that is, are reasonably efficient at all points from half to full load. While considerable more improvement can be expected, especially for the smaller sizes, these machines are now well developed and progress is likely to be slow.

Steam engines, looked at in the same way, are, under favorable load conditions, more efficient than ordinary steam turbines through that portion of the working range down to atmospheric pressure, but are much less able to make use of the energy in steam when the high vacuum region is reached. Partly for this reason, condensing engines are less efficient than all but very small steam turbines, and as sizes increase, a point is soon reached where the turbine is far superior.

Engines Not Suited to Varying Load

The Corliss and similar type engines have steep water-rate curves; that is, the efficiency of most of them decreases rapidly with any considerable departure from best load. In general, engines do not meet varying load conditions as efficiently as turbines.

The unaflow engine offers a marked exception to this statement. Having a very flat steam rate curve through the ordinary working range, this type is specially efficient and valuable for non-condensing service where the demand is for relatively small quantities of power—that is, in general, not exceeding a few hundred horsepower—for which they are most suitable.

The part which in the future may be realized in energy output will, without doubt, be considerably increased through further improvements in equipment, but these increases do not seem at all likely to represent any very large part of the total quantities that are now rejected to waste. How small that part of the energy we use is, as compared to the whole quantity of such energy contained in fuel or water taken as a source, we believe can be most clearly shown by reference to Fig. 2. The much greater percentage of total

energy realized as useful work when water is the source is also clearly brought out.

In this diagram the text opposite each line describes the method of producing power and the point of use; the steam engines and turbines are, of course, also charged with the usual necessary boiler losses, that is, all losses up to the point where power is delivered. The total length of each line is made to represent total energy in a unit of the power source used.

The black portion of the same line represents by its length the percentage of the whole realized as net or useful work and the hatched portion, the part used up in such ways as through auxiliaries, banking, radiation and transmission. The combined black and hatched portions represent gross output. The white portion represents energy lost or used up on the way to the point of delivering gross output.

The diagrams for the best plants represent very nearly the highest values thus far ever attained, but those for poor plants by no means portray conditions as found in the poorest, which are often considerably worse than as here shown.

First Commercial Steam Turbine in This Country

The interest evoked by the mercury boiler and turbine installation in one of the plants of the Hartford Electric Light Co. brings to mind the fact that this company was a pioneer in the adoption of the steam turbine in this country. Therefore, the following letter read by one of the executives of the company at the recent meeting of the Technical Session N.E.L.A. in Boston is especially fitting at this time.

This unit was 1,500 kw. 2,400-volt, two-phase, 1,200 r.p.m.; dimensions as follows: Height, about 7 ft.; width, approximately 7 ft.; weight, about 100 tons. This unit arrived in Hartford in January, 1901, and was moved from the siding to Pearl Street during the night time on rolls through the streets, so as not to obstruct traffic. The turbine being assembled, the truckmen did not have any trucks or apparatus that would support it. Upon arrival, the Westinghouse erectors were on the job ready to place it on the foundations prepared by the company. Owing to no condensing water outside of the city water, which was of course out of the question to use, cooling towers were erected to take care of condensation. This necessitated the purchase of more land on Pearl Street, which is now occupied by the Library Bureau. These towers were three in number. The auxiliary power to take care of the barometric condenser attached to this unit was as follows: One 300-hp. pump for water to condenser, one 300-hp. pump to pump the condensation and circulating water through the three cooling towers. On these cooling towers were three 40-hp. direct-current fans.

The total auxiliary power to take care of this unit was 40 per cent of its rated output, but apparently they underrated this unit, as the writer, during a short period test, has seen 6,000 kw. registered in the indicating wattmeter, and this on the primary valve. We really had no way of getting the full capacity from the unit.

The erecting of the unit, and also boilers, consumed the greater part of the year, and finally, about the latter part of October or the fore part of November, 1901, the turbine made its initial bow to the public, it being the first commercial turbine installed in the United States, and from that time on we had some trials and tribulations that surely gave no end of trouble, and not until the year 1903, after the Westinghouse engineers had been on the job two years without missing a day, they found that to get this turbine to perform more than one full day at a time, the whole low-pressure blading had to be removed and the balancing pistons on the high-pressure end were likewise removed. This, of course, cut down the efficiency very much. The turbine did run after this with more 24-hour periods. It was in trouble so many times, the upper case having been removed so many times, that the bolts and nuts were stretched so badly that three sets had to be used. During 1902 the shaft became loose in the spindle on the high-pressure end and a new one was ordered and was pressed in by hydraulic pressure, but during this process the pump failed when the shaft was within $\frac{3}{32}$ in. of its true position. This necessitated shipping from the factory one load of special machinery to obviate the trouble. This took weeks to straighten out.

During the first year the turbine ran 84 hours; during the second, 555; during the third, 721; during the fourth, 2,173.

During 1901 (est.) 80,000 kw.-hr. were generated; during 1902 429,000; during 1903 616,200; during 1904 2,462,350.

In 1905 the machine was moved to our Dutch Point Station and operated there until 1908, when it was replaced by a new turbine. This (first) turbine, when started up, was found to be too long between bearings and owing to sagging of the spindle, the blading would be ripped out. The cap had to be removed, and blades that were broken out were removed and the cap replaced. This being a continuous performance, this work had to be done two or three times a week. After this had gone on too far, our thrust bearings would not stand the work placed upon it and it would fail. This necessitated the placing of new blades in the case and rotor, and this followed each year until 1903. When we lost blades in the turbine, we had to have them cleaned out so that it could be operated the next day for our peak load.

Owing to our records during these early years having been destroyed, I am unable to give you a clear and authentic report of its daily performance, but I can safely say that during its first two years of existence, if we had 48 hr. of continuous operation, we thought we had a wonder.

At the present time, this turbine is located at Pittsburgh, to give some idea of the great improvements made in turbines since that time.

A Worthington 562-hp. Diesel engine in the municipal light plant at Horton, Kan., was operated without shutdown for 202 days. What this performance means may be grasped by considering the mileage a fly would have made if it had been possible for it to stick to the wheel rim. With a 9-ft. wheel the fly would cover 1,400 miles per day and its journey during the entire run be equal to over ten times the distance around the earth.

Throwing Wrong Switch Leads to Turbine Wreck

INFORMATION has become available concerning the wreck of a turbo-generator at the plant of Penick-Ford, Inc., Cedar Rapids, Iowa, on Feb. 15. The machine was one of two 2,000-kw. units running at 3,600 r.p.m. Just before the accident the two had been running in parallel and it was desired to take one off the line. Accordingly, the load was reduced to 50 kw. on the outgoing unit and the engineer closed the automatic by hand.

The switchboard operator pulled the generator switch and intended to open the field switch also. Instead, he made a mistake, apparently, and pulled the field switch on the generator that was running. This resulted in unloading that unit. A sudden rise in speed then occurred. The fans on the generator first let go and damage to the turbine followed.

The emergency tripping device was found to have been tripped by itself or by hand, but nevertheless did not close the valve quickly enough. The main governing mechanism, also, evidently failed to function satisfactorily, as otherwise it would have prevented serious overspeed, even if the emergency valve were open.

The first break appears to have been in the ventilating fan, pieces of which punctured the casing of the other machine, also the wall and ceiling. The rings over the ends of the field winding stretched out and seized the stator, throwing the rotor out of line so that it smashed the casing into small pieces. In flouncing around, it broke the cylinder supports, all of the bearings and slipped the disks on the turbine shaft, stretched the ligaments of the buckets due to the centrifugal force from the high speed of rotation, and threw out some of the shroud rings. Some of the flying pieces of metal knocked a motor-generator set off its base, damaged ten panels of the switchboard, besides damaging the tile floor and wall, and put holes in the roof. The generator of the other machine was damaged but was back in service within a week.

Two men were hurt slightly, but not sufficiently to keep them off the job. The switchboard operator sustained burns on his hands, and the engineer was hit by a flying piece of metal. Property damage amounted to $35,000, and the loss in production probably amounted to as much again.

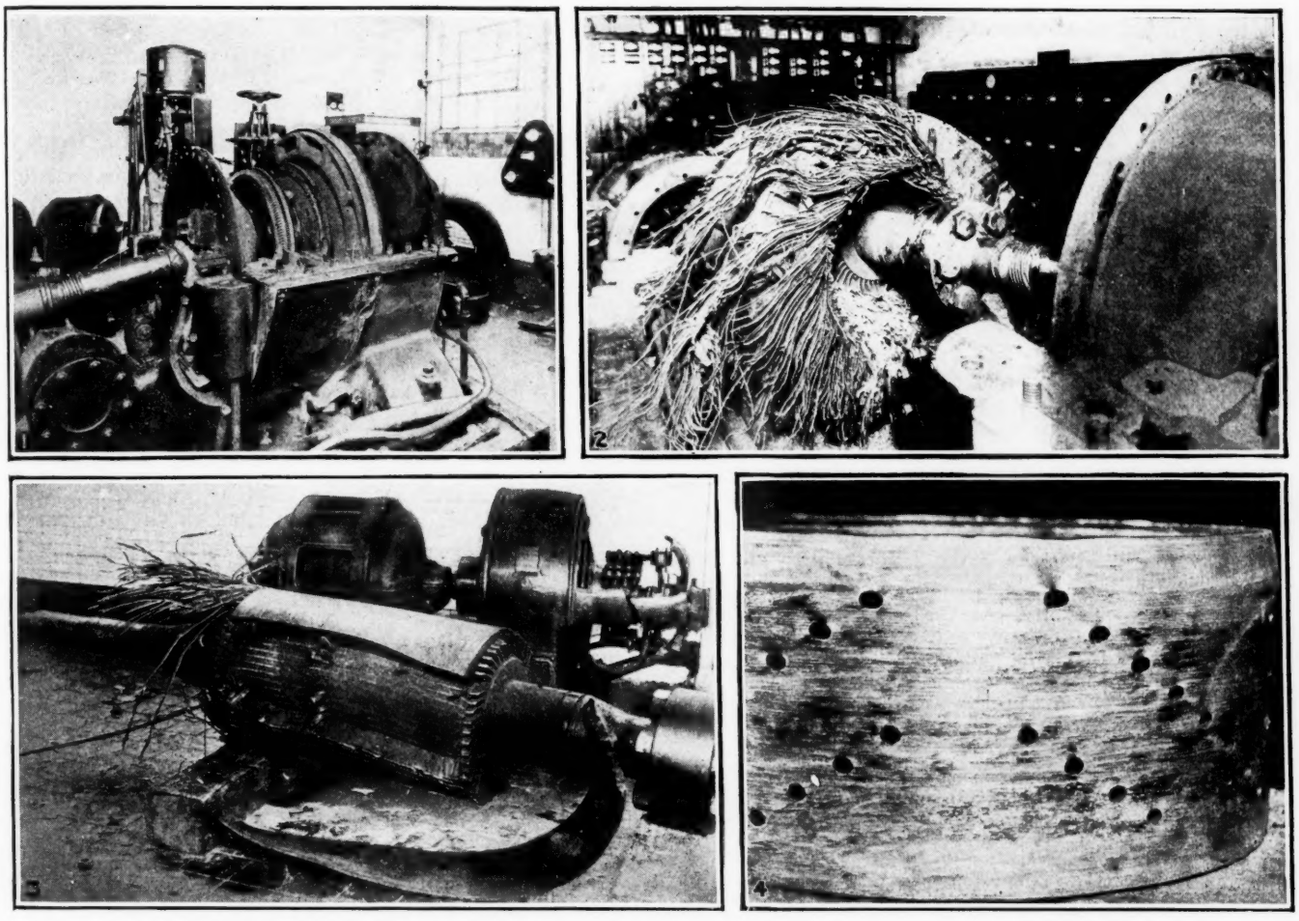


Fig. 1—The turbine shortly after the wreck. Fig. 2—Shows how generator windings let go. Fig. 3—Close up view of damaged rotor. Fig. 4—View of end ring.

Water Hammer Causes Break of Big Creek No. 8 Penstock

Investigations have been carried on by the engineers of the Southern California Edison Co., as to the causes of failure of the penstock at this company's Big Creek No. 8 hydro-electric plant on Jan. 1, reported in *Power*, Jan. 15. These studies have developed that the accident was due to a combination of circumstances. In view of the interest among engineers in this failure, the company has given out a statement which is substantially as follows:

Conditions at Time of Break—Just before the break the 30,000-hp. unit (only one unit is installed at this plant) had been shut down by closing the guide vanes of the turbine. The Johnson balanced valve, which is provided at the lower end of the penstock as a shut-off, was left open, and for the time being the water flowed through a pressure-relief valve connected to the turbine casing, which opened automatically as the turbine gates were closed. This valve is closed automatically against the action of a heavily damped dashpot, and ordinarily would have remained closed, when the penstock valve could have been closed safely under no flow. On the present occasion the automatic control of the pressure-relief valve had been shut off preparatory to unwatering the draft tube for inspection. Until the penstock valve could be closed, the pressure-relief valve was to be kept closed by water pressure brought through a small pipe controlled by a manually operated valve.

This latter valve the operator opened, preparatory to closing the penstock valve; but in so doing he neglected to close a second valve in the same pipe system leading to an ejector. This neglect allowed the pressure-relief valve to open, contrary to the operator's expectations. In consequence, when he later undertook to close the penstock valve in a way that would have been quite safe under balanced pressure, the full force of flow through a 6-ft. pipe under a head of 680 ft. caused the valve to slam shut, setting up a severe water hammer in the 2,800-ft. penstock.

The Effect—The sound of the sudden closure of the penstock valve was heard some distance from the plant. It was followed by two other reports, presumably caused by the rupture of the penstock. The penstock broke in two places, one of them about a fourth of the way up, the other in the anchor section just outside the power house. Both sections consisted of lap-welded steel pipe, and in both cases the ruptures were clean breaks.

The upper break tore the pipe open for the length of one section, by a longitudinal rupture on the side opposite the longitudinal weld, crossing the circumferential weld approximately at right angles. In the break near the power house the lower end of one of the thickest sections of the penstock, which was further strengthened by being embedded in a concrete anchor block, was cracked for a length of about 5 ft. The greater portion of this crack was in that part of the pipe embedded in the concrete block. Outside the anchor block the break extended through the cast-steel flange of the pipe, which is some 4½ in. in thickness.

Repair of the Break—In the case of the upper break the ruptured section of the pipe was removed bodily from the line and was replaced by a new section of the same dimensions riveted up in Los Angeles on a rush order. The lower break was repaired by attaching a butt strap over the crack inside the pipe. The butt strap, cut from the upper ruptured section, was bolted in place inside the pipe and was then welded to the pipe shell along the edges. External bands were applied to the pipe to strengthen the repaired section still further, giving to the finished job a greater strength than it had before the break.

In addition to the loss of two lives previously reported, the damage was limited to the penstock itself.

A noteworthy feature of the case is that, while the accident abruptly took out of service the 30,000-hp. capacity of the plant, electric supply on the entire transmission network continued uninterrupted; few consumers even knew that the system was meeting any unusual condition. Moreover, by remarkably rapid work in planning and executing the penstock repair, the plant was put back into service within two weeks, a feat that was made particularly difficult by the remoteness of the plant, which is situated in the mountains 250 miles from headquarters.

Effect of Power Factor on Oil Engines

In selecting the proper size of alternating-current generator for oil-engine drive, too little attention is paid to the question of power factor. If the system has a power factor of 80 per cent and the generator capacity at this power factor is to be 400, which would call for a 500-kva. machine, it is usual to choose an engine that, at its full rating, will be able to handle 400 kw. This load, including generator losses, would call for a 575-hp. engine.

As long as the kilowatt load does not exceed 400 this engine will operate continuously without distress. Even if the power factor drops to 70 per cent, the engine will satisfactorily carry 400 kw. notwithstanding the rise of the kilovolt-amperes to 575, although the generator temperature will increase. On the other hand, suppose the power factor increases to 90 per cent. If the operator attempts to maintain the same voltage and amperage as with 80 per cent power factor—that is, 500 kva.—the kilowatt load will rise to 450. The engine load is then 660 hp., which is much more than the engine can safely carry.

While in steam-engine driven units such an overload may be endured for short times by reasons of the ability of the engine to operate with long cutoffs although inefficiently, it is a dangerous proceeding when the prime mover is an oil or gas engine. In these installations the kilovolt-ampere readings should be disregarded and the net kilowatt reading used to determine the proper loading of the engine.

The temperature of a substance heated above the surrounding atmosphere is a measure of its ability to produce power. Any drop in temperature that occurs without the conversion of heat energy into mechanical work results in a loss of power. This loss is not recoverable and represents a distinct waste. Wiredrawing of steam through a reducing or governing valve is an example. In an ordinary practical plant at about 300 lb. pressure the gain in economy due to preheating air by means of bled steam will not be more than 2 or 3 per cent, while the reduction in fuel consumption obtained by preheating the air with flue gases appears to be about 5 to 7 per cent, or approximately twice as much. There is considerable power loss in using bled steam for heating, representing that consumed by blowers, and also the difference in the high-temperature drop between the bled steam and the heated air.

Examination Questions

HARDLY a week passes that *Power* does not receive a string of examination question from readers who are about to apply for operating licenses. Many seem obsessed with the idea that the answers to these questions will aid them materially in passing the forthcoming examinations. Presumably the questions are gathered from past examinations and are secured as samples from the licensing boards or from friends who have taken the tests.

In the first place, it is idle to assume that the boards will repeat the questions, but granted that this were likely, the candidate would be the ultimate loser, for it is not ability to memorize twenty or thirty answers that is a measure of an engineer's qualifications; it is his knowledge of the fundamentals, ability to reason, to distinguish between safe and unsafe practices, and a knowledge of what to do in an emergency. To be able to meet these qualifications in order to insure safe operation of power-plant equipment, is the sole object of licensing.

In view of this *Power* has adopted the policy of not furnishing the answers to such questions, but instead encourages the applicant to reason them out for himself, in which case we are always willing to criticize his answers. Viewed in this light, the value of sample questions lies in indicating those branches of the field upon which candidates should be well posted. The "Questions and Answers Department" is conducted to assist the engineer in solving his every-day problems and not as a primer for examinations. To qualify successfully for these requires book study, consistent reading of the educational and practical articles, all supplemented by operating experience and observation.

Conservation of Heat

THE engineer who can show a fuel consumption of a pound and a half of coal per kilowatt-hour carries about a smile of complacency and an air of wanting to tell the world that he possesses both a well-designed plant and a high-grade brain. After all, he can hardly be blamed, for those identified with power plant engineering realize that such a fuel consumption means an over-all thermal efficiency of some sixteen per cent.

Those whose conception of the possibilities of power-plant practice have not been quickened by minute engineering information are, however, prone to express wonder at the willingness of engineers to throw away eighty per cent of the heat in the coal through the loss in the cooling water. The suggestion naturally offered by these "outlanders" is that this heat should be used to warm our homes and factories.

The combination of central station and heating system is an old ground of argument. While on the surface this arrangement looks as if it should produce maximum results at least expenditure, it must be remembered that few of such systems have ever worked satisfactorily. The loss in pipe-line radiation and the cost of main ample to handle the steam at low pressures are the factors that prevent its success.

However, should engineers not reopen the investigation? In the light of the high boiler pressures now possible, say one thousand pounds, would it not be possible to expand the steam to, say, two hundred pounds and during the winter season warm our buildings with this fairly high pressure exhaust?

The one possible objection is that the power and heating loads do not coincide. Granting this be true, would it not be possible to operate the non-condensing turbine, which will be called the heating turbine, floating on the line? The power it puts into the switchboard could be regulated by the demand for heating steam. The balance of the power could be produced by the usual condensing turbine. True, this entails an increased station cost, but turbines are but a small part of the whole station investment, and even if the plant should have its turbine equipment increased by one hundred per cent, the plant investment per kilowatt capacity would not be increased over twenty per cent. This means that a twenty per cent increase in station cost would increase the thermal efficiency from sixteen per cent to as high as seventy. Is it worth considering?

Standardization of Electrical Equipment

ONE of the wonders of modern times is the rapid growth of the electrical industry. Started only about forty-five years ago, it has grown to a place of first importance in industrial development. This phenomenal advance could not have been made without a wide diversity of opinion as to how this development should be made. As a result a great variety of voltages and frequencies came into use. However, the industry in this country has succeeded to a large degree in eliminating the unnecessary systems.

When the use of motors for power applications is considered, no such standardization is found as has taken place with voltages and frequency. Considering only one application, that of ventilating fans, the statement was recently made by one of the engineers of a large electrical manufacturing company that "To meet all the conclusions of ventilating engineers, as to horsepower and speed, has necessitated ratings of motors running up into thousands. One electrical manufacturer, for example, for fan and blower service, has listed in his price form no less than three thousand different ratings of 230-volt direct-current motors alone, in sizes from and including one-half to fifty horsepower and for motor speeds extending from 90 to 1,050 r.p.m., with speed variation capabilities varying from 1¼ to 1, to 2 to 1 of the respective minimum speed." Adding to this the ratings for 110- and 550-volts direct-

current, and those for the different voltages, phases and frequencies in alternating current, the number of motor ratings for fans and blowers alone runs into an almost unbelievable figure.

One has not to look very far into this condition before being convinced of the vast economic wastes that result from the use of this tremendous variety of motors alone. This waste is something that not only architects and engineers are responsible for, but also the fan and motor manufacturers. This condition contributes no small part to our periods of business depression and abnormal activities, with all their evils. The more demand there is for standard products, the greater reserve stock the manufacturer can feel justified in building up during periods of business depression to assist in meeting the requirements of industrial expansion. The more nearly production can be maintained at normal, the lower will be the cost, the less the spoilage of manufactured products, the lower the overhead costs, the more efficient and satisfied the employees, and it will be easier to maintain a trained organization. One of the best examples of the effect standardization may have on the electrical industry is that of the electric lamp, which, although being subjected to radical improvements, has been materially reduced in cost to the consumer in spite of rising costs for labor and material. Standardization of electric motors is something that is not the problem of the electric manufacturer alone, but to a large degree that of the user. Unless those who create the market for this equipment will utilize standard apparatus where it will give just as good service as special equipment, the motor manufacturer will be seriously handicapped.

Too Many Lawyers

WE ARE governed largely by lawyers. The Supreme Court, our final arbiter of constitutionality, is naturally and properly composed exclusively of members of the legal profession. But it is significant that the United States Senate and House of Representatives (to say nothing of the state legislative bodies) are largely recruited from the same source. This again is natural enough, though its desirability is questionable. That the study and practice of the law instills a desire to help make it, is understandable. The active attorney drifts almost automatically into the field of professional politics.

It may be a mere coincidence that so many deplorable spectacles of narrow partisanship have been staged in legislative bodies composed mainly of lawyers. Perhaps a Senate and House manned almost exclusively by the members of some other profession would have done no better. But it is hard for the average man—particularly the average engineer—to keep down the suspicion that much of the fault lies right here. The point of view of the lawyer, fostered by his whole training and by the traditions of his profession, is that of the special pleader and the debater. He must always be making out a case for some client or special interest. He is not interested in revealing the whole truth, but only those fragments that happen to favor the special interest he is trying to promote. Assemble several hundred such men to make the laws of a nation, and one may reasonably expect that statesmanship will degenerate into narrow partisanship and the petty swapping of one favor for another.

Undoubtedly, a little of this spirit can be found even among engineers, but only as it persists in spite of their training. The very atmosphere of scientific and engineering work instills a deep desire to dig up all the facts, favorable and unfavorable, and to plan wisely and honestly on this basis. The true engineer finds greater pleasure in unearthing a fact than in "winning" a mere argument.

Public life needs a little more of this combination of the desire and the ability to dig out facts with intellectual honesty in their use. A few more engineers of the right sort in public life ought to improve the mixture.

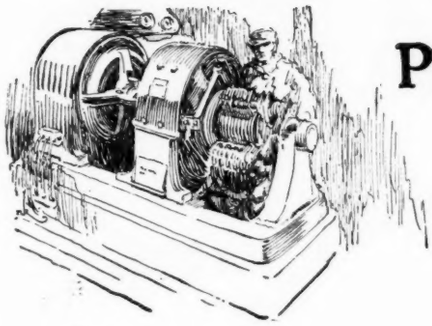
Engineers Should Study the Petroleum Problem

THAT one builder has reached the record-breaking output of thirty-thousand automobiles per week has been acclaimed in the press, as was another announcement that this country possesses over thirteen million cars. Since this latter number represents some three hundred million horsepower of gasoline engines, it is well to give consideration to its effect upon the natural resources of the country.

While there is no basic reason why an automobile engine should not possess an efficiency equal to that of the highest-grade internal-combustion engine found in power houses, the fact remains that the efficiency of all automotive engines is very low—so low that the attainment of the maximum possible efficiency would result in a reduction in gasoline consumption by two-thirds. It is possible, in addition to the adoption of higher compressions, to reduce the individual engine capacity and, in so doing, make a further reduction in fuel consumption.

How these desirable conditions are to be obtained is a matter of debate. As long as gasoline costs are low, it will be difficult to induce owners to use leaner mixtures, for all mankind delights in a snappy response in a car. While the enormous demand for gasoline serves to make a large gallonage of fuel oil available for power-plant use at low prices, the final result is a depletion of the petroleum supply, which will be reflected in a much enhanced price for fuel oil and other petroleum products in the future.

It may be argued that the automobile is not a power problem such as coming within the bounds of the subjects to be considered at the World's Power Conference to be held in London the coming summer; still the fuel used in the automobile decreases the amount available for the industrial power plants. It might be advisable for the Conference to give consideration to all phases of the internal-combustion problem, for, while by no means equal in horsepower to steam or water power, there are thousands of plants employing such prime movers that are making a most efficient use of fuel, and since units of ten thousand horsepower are in process of construction, it would seem that the internal-combustion engine will be available in units suitable for large power systems. While the tentative list of papers by American engineers does not include one, it appears logical that in view of the fact that the solid-injection engine had its origin in the United States and here are found the largest gas engines in existence, the presence of a paper by an American internal-combustion authority on the Conference program should find favor with engineers of all countries.

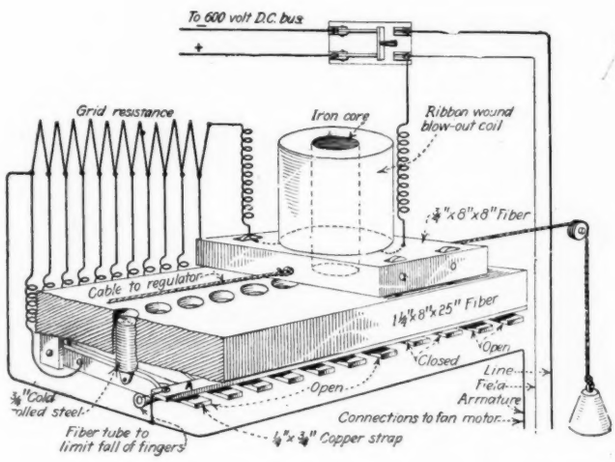


Practical Ideas *from* Practical Men

Constructing a Controller for Fan-Motor Service

In our plant the forced-draft fan is driven by a 150-hp. 600-volt direct-current motor, the speed of which is controlled by a grid resistance in the armature circuit. This resistance was until recently cut out and in with the usual type of radial-arm rheostat controller actuated by a master regulator.

As the controller arm would frequently clear a contact by only sufficient distance to establish and maintain an arc, thus burning the contacts and often welding them to the arm, several drops in steam pressure resulted.



Details of controller and method of connecting

To overcome this trouble our maintenance crew, who had lost heart in their endeavor to make this equipment dependable, decided to build a controller of their own design. With a piece of 1¼-in. red fiber board, some ¼x¾-in. copper busbar, a few feet of ¾-in. cold-rolled steel, a laminated slip-ring brush and a ribbon-wound trolley-car blowout coil, they have constructed and installed a controller that is operating perfectly and has eliminated all the former troubles.

The details of the controller and the principle of operation will be readily understood by referring to the illustration. On a line through the center of the fiber board, twenty $\frac{25}{64}$-in. holes are drilled. On the lower side, close to the edge, a piece of copper strap *A*, extending the entire length, is fastened with flush wood-screws. Twenty copper contact fingers, fastened at the center to pieces of the cold-rolled steel 2¾-in. long, are hinged at one end to the board, so that they extend crosswise with the steel pieces in the holes and the opposite end, reaching across the copper strap *A*. The contact fingers are connected to the taps on the grid resistance by flexible leads as shown.

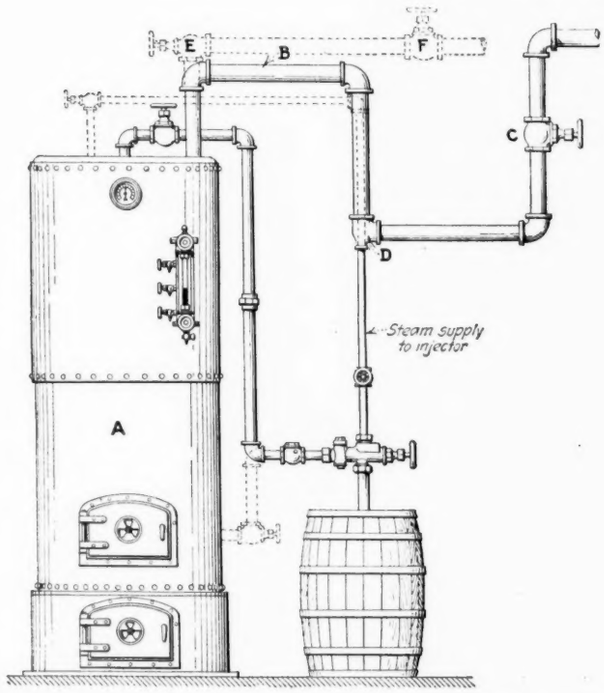
A soft iron core is fitted to the blowout coil, which is connected by means of flexible leads in series in the line and used as a rider on the board to operate the contacts magnetically. The magnet is moved by the regulator in a path directly over the steel pieces to which the contact fingers are attached, closing and releasing them quickly and cleanly, always holding to the closed contact until it has closed another.

This controller has helped us out of one of our greatest troubles and, after several weeks of service, has proved entirely dependable. DAVID CRAFT.

Parkersburg, W. Va.

Piping an Injector

When a small boiler is to be fed by an injector, steam should be taken for this purpose directly from the boiler. For larger units this may not be practical, but even then the steam should be secured under conditions that would warrant a full supply, and the injector pipe should not act as a drain for any other pipe. Where these precautions are disregarded, the injector may



Original and improved arrangement of injector piping

give satisfactory service for a portion of the time and be unreliable at others.

An example of this kind of service is shown in the illustration. *A* is a small vertical boiler, out of which steam is taken by the main pipe *B* for general use. The first vertical piece is 2½-in., but it is reduced at the first ell to 2 in. As this pipe is continued, a pocket is formed through which the flow of steam is controlled by the valve *C*. A tee is used at *D* and the outlet forms the supply for the injector. Sometimes it would feed the boiler, and at other times it would not. This may be explained as follows:

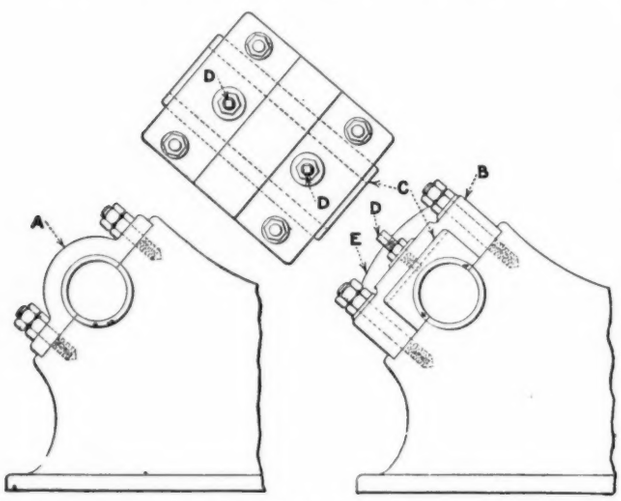
By opening the valve *C* wide, it is possible to reduce the pressure of the steam so that it would not operate the injector. Again the valve *C* may be partly closed according to the flow of steam required. This would insure a full pressure, but it might contain so much water that it would fail to operate the injector. If a 2½-in. tee had been inserted in the pipe *B* to supply dry steam for the injector, it would have been satisfactory in practice.

A much better arrangement of the piping is shown by the dotted lines. The main pipe is fitted with an angle valve *E* near the boiler, and another at *F* for general use. There is no pocket for the accumulation of water or for water hammer in service. Steam is taken directly out of the boiler to operate the injector, and it discharges below the water line. With this arrangement fewer fittings are used and better results are obtained. W. H. WAKEMAN.

New Haven, Conn.

How the Main Bearing Was Made Adjustable

The engine of which I have charge was originally fitted with a one-piece main bearing as shown at the left in the illustration. I found it rather difficult to keep a nice adjustment on this bearing, as it was necessary to take off the cover and remove liners from between the halves of the bearing.



Alterations made to bearing cap

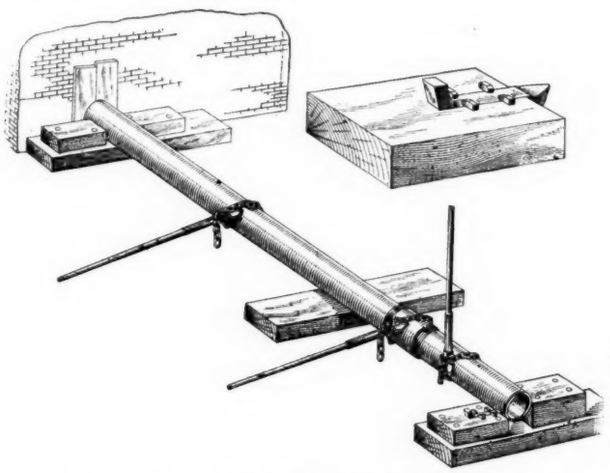
In order to reduce the length of time required for making these adjustments and to have a quieter running engine, I had a cap made in two parts as shown in the right-hand figure of the illustration, which is self-explanatory.

The top cap *B* is bolted in position on the lower half of the bearing and then the half-box *C* is adjusted by the set screws *D*, which are finally secured by locknuts. The cap was strengthened at the center by the rib *E*.

Portsmouth, Ohio. G. T. WHITE.

Threading Large Pipe by Hand

A pumping station had been erected to supply water to a town in Virginia and was to be started on a certain Monday morning. Late Saturday afternoon it was discovered that a filling-in piece of 10-in. discharge pipe was two inches too long. As there were no facilities in the neighborhood for threading large pipe and the time was limited the erecting man resorted to the method shown in the illustration.



Shows improvised method of threading pipe

The end of the short piece of pipe was marked squarely around and cut with cape chisel and hacksaw and the end smoothed up with a file. The twelve-foot length to which the filling-in piece was to be connected, was placed on blocks, end on against the pumphouse wall, pieces of plank being inserted to prevent marring the brickwork. The short piece was now screwed into the coupling on the end of the 12-ft. length, and both threads were made up about three-quarters of their draft. A block was now spiked on the supporting timber, the one on the left of the pipe to serve as a tool-post, as shown.

The point of a cape chisel was ground to the shape of standard pipe thread, and secured in a slot, cut in the wooden block, by railroad spikes, space being left at the end of the slot for a steel wedge, to feed the tool forward. The thread was started with a file and the tool set in position. Two large chain tongs were used to hold the long pipe and coupling steady, the ends of the tongs resting on the ground, a third tongs being used to revolve the short piece of pipe. As the threads were backed out of the coupling, the short pipe was fed ahead to the cutting tool. Four cuts were made, the wedge behind the tool being driven a little each time. As soon as the thread was finished, it was smeared well with white lead, and the flange made up. Then the pipe was put in place and the final connection made.

The pump was started on time Monday morning, and all pipe joints proved tight under 90 lb. pressure.

Utica, N. Y. M. M. BROWN.

Comments from Readers

Rumbling of Safety Valve

Referring to the inquiry in the Dec. 4 issue, "What causes a pop safety valve to chatter on its seat with a rumbling noise?" also the discussion by Mr. Thompson in the Jan. 22 issue, it has been my experience that the valve that rumbles either has only a point connection between the pressure pin and the socket in the top of the valve disk or has been lubricated so that the disk oscillates freely on the end of the pin when just leaving its seat.

Where the end of the pressure pin fits into a spherical socket or has a reasonably large bearing surface on the disk, this tends to hold the disk steady while just balanced close to its seat, while with a point connection the disk is perfectly free to vibrate. I have found that the valve with the socket connection will rumble also when freshly oiled, but will cease to rumble in a few days when the oil has all dried out of the stocket.

The reply given to the inquiry in the Dec. 4 issue is quite correct, but the method given only eliminates the rumble by opening the valve more suddenly.

Vancouver, B. C. R. MANLY ORR.

While I agree with Mr. Thompson that rumbling of safety valves is often due to improper installation, I had an experience with the pop valve on a marine boiler some time ago, in which the trouble was overcome by widening out the wings on the valve. The valve was located on the end of a pipe outside of the engine room close to the smokestack, and the pipe line was made up of a short nipple, a 45-deg. ell, a 10-in. nipple, a second 45-deg. ell, a 3-ft. section of pipe and the pop valve. The pop soon got so it would rumble, and later it rattled so badly that I could not hear the bells in the engine room. The valve was an old type that has no blow-back ring and we had to use it as there were no spare pops to be had. We took it off one day when the boiler was cold and took it apart. Then we took out the valve proper, and with a hammer we widened out the wings in such a way that they were just a nice sliding fit in the valve body. This cured the rumble and the chatter.

Rochester, N. Y. R. G. SUMMERS.

Shortness of Water and Overheating in Steam Boilers

In the Jan. 22 issue there is a good article on the "Shortness of Water and Overheating in Steam Boilers." There is one conclusion of the author, however, to which I believe exception might be taken; namely, that "in the vertical-tubular boiler there is such a considerable distance between the furnace crown and the normal water level that shortness of water will make itself apparent in an external manner before much damage can be done internally. In this case, as the water level lowers, the first effect will be superheating of the steam and a more rapid generation of pressure.

If this reasoning be correct, the quickest way to get up steam would be to start with low water, or rather, if the steam happened to be low, to run the water off until some of the heating surface is exposed to the steam.

However, the idea is manifestly wrong, as the heat-transfer rate between metal and steam is so much lower than the rate between metal and water. About fourteen years ago I heard of a case which appears to disprove the author's claim. It happened in one of those plants in which the engineer had everything mechanical in the plant under his supervision. One day, while performing his duties some distance from the engine room, he noticed the speed falling off. Going to the engine room, he found that the trouble was not there, but the engine had slowed down. Proceeding to the boiler room he found that the water was low in the boiler; so much of the heating surface was out of the water that not enough heat could be transferred to the water to keep up the pressure.

Years ago, when I started at engineering, one of the unpardonable sins was to put water into a boiler if there was no water showing in the gage glass. In discussing the effect of putting water on a hot plate, the usual conclusion was that as the plate was heated and expanded, the application of water to one side of it caused a contraction of the metal on that side, possibly cracking it, owing to the strain, and thereby weakening the plate sufficiently to permit the pressure in the boiler to complete the work of tearing the plate all the way through. At the same time, might it not be possible that the experiments that have been conducted to find out how much a boiler will stand by injecting cold water into it when the plates are hot, might not result in rupture the first time or even the second or third time, but might result in explosion the next time owing to the reason given?

Toronto, Ont., Canada. R. MCLAREN.

Is Heat Balance a Mania?

The editorial entitled "Is Heat Balance a Mania?" in the Feb. 12 issue is timely. Briefly, the reason for making a study of the heat balance is to find where the heat goes, what it does, and how much heat is involved. Before it is possible to indicate savings, it is necessary to find where the wastes occur and what their magnitude is. Much has been written about the heat balance in power stations, but a fruitful field for a critical analysis of heat processes lies in the large industrial plants.

In the large public-utility plants the operating staff is usually more highly trained than that found in the small isolated plant. For this reason the design of the small plants had to be along lines of simplicity in operation as a first consideration and economy of fuel as a secondary matter.

The modern large industrial plant is now passing through a stage in its evolution from a plant that simply operates to one that operates economically. The

old-time master mechanic and the old-time operating engineer are now giving way to a more technically trained man with the executive ability to engage such assistance as is needed. The reasons for this newer impetus in economical operation are due to rising costs of labor, equipment, fuel, buildings and keener competition in large-scale production. The desire of one manufacturer to make his selling cost the manufacturing cost of his competitor is the rule.

It is fortunate that engineers in general appreciate the difference in simply saving heat and that of saving heat at the highest available temperature elevation. There are many industrial processes in which the heat rejected from one operation can be made the source of heat for some other operation. In general the heat balance in industrial applications is much more difficult than in the power stations of the public utilities.

An excellent field for research is to be found in the design of heat-exchanging apparatus that will transfer large quantities of heat at small temperature differences. If this can be done with little first cost in apparatus and low operating expense, I know of many manufacturing processes that can be revolutionized.

Therefore, instead of countenancing the study of heat balance as a passing mania, I wish more power to those who choose to look into this. It is distinctly worth while. ALPHONSE A. ADLER.

New York City.

The Boiler-Room Bonus

Being familiar with the operation of a boiler-room bonus system in several plants, I was much interested in the editorial on that subject in the Jan. 15 issue of *Power*.

In one of these plants, a large central station, the bonus is based on the actual pounds of water evaporated per pound of coal as fired. The chief points in favor of this system are its simplicity and the fact that the firemen themselves may figure out what is coming to them. The chief objection is that the company buys its coal in the open market, consequently the heating value and steaming qualities vary considerably, a factor over which the firemen have no control, yet which determines largely the amount of water evaporated per pound of coal fired.

Two industrial plants with which I am familiar, base the bonus on the amount of coal burned per pound or ton of product manufactured. This method is certainly unfair to the firemen and perhaps unfair to the management. At one of these plants, for instance, the firemen obtain good results in the boiler room, but the steam is wasted in varying amounts in different parts of the mill; also, the steam consumption varies with the size of stock produced.

Since the purpose of the bonus is to provide an incentive for the fireman in securing better efficiency, and since the coal rate will vary with the grade of coal burned, feed-water temperature, etc., which are factors not under the control of the firemen, it is my opinion that in the majority of cases the proper method would be to base the firemen's bonus on the actual boiler efficiency obtained. I also believe that the boiler maintenance men should share in the bonus, as the efficiency of a steam boiler depends largely on how well they have performed their duties in cleaning tubes, repairing baffles, settings, etc.

In a certain large central station the boilers are equipped with individual steam-flow meters and the coal to each boiler is weighed separately; a careful record is kept of the amount burned, also the amount of steam produced by each boiler for each shift. At the beginning of each shift the boiler-room foreman checks up on the amount of coal in each stoker hopper and the thickness of the fuel bed.

In plants where the latter system is possible, each fireman could be paid a bonus based on the results that he actually obtains. GEORGE E. GASTER.

Tyrone, Pa.

The Throttling Calorimeter—What Is Saturated Steam?

I am grateful to Ernest H. Peabody for his communication in the Jan. 29 issue calling attention to my failure to give credit to Prof. Cecil H. Peabody as the originator of the throttling calorimeter.

In my article on that subject, appearing in the Dec. 25, 1923, issue, I did not take up the history of the calorimeter. As a matter of fact, the throttling calorimeter is extensively known as the Peabody calorimeter. Having been a student under Professor Peabody about twenty years ago at the Massachusetts Institute of Technology, I am deeply indebted to him for his thorough teaching and for many kindnesses in later years, and must confess that I have been displeased at the tendency of various manufacturers of these instruments to call them by other names in preference to that of Professor Peabody.

Unquestionably, this simple instrument, given to the world by Professor Peabody, has had much to do with the evolution of steam engineering, and is greater for its simplicity. There are few instruments whose accuracy is so little influenced by the details of design or construction.

In the same communication Mr. Peabody raises the question of the real meaning of the term "saturated steam"; that is, with what is it saturated, heat or moisture? He takes the position that it is saturated with heat and not with water.

To answer this question we may assume that the meaning of the word today should be the same as when it was first used, or we may say that its meaning should be as indicated by common usage of modern authorities. If the two agree, the answer is definite and positive. If they disagree, it may be necessary to accept the word as describing a condition of steam, without saying with what the steam is saturated.

I have met this question many times before, and have had little patience with it, feeling that it was a useless technicality of words, but would like to record my observations on the subject.

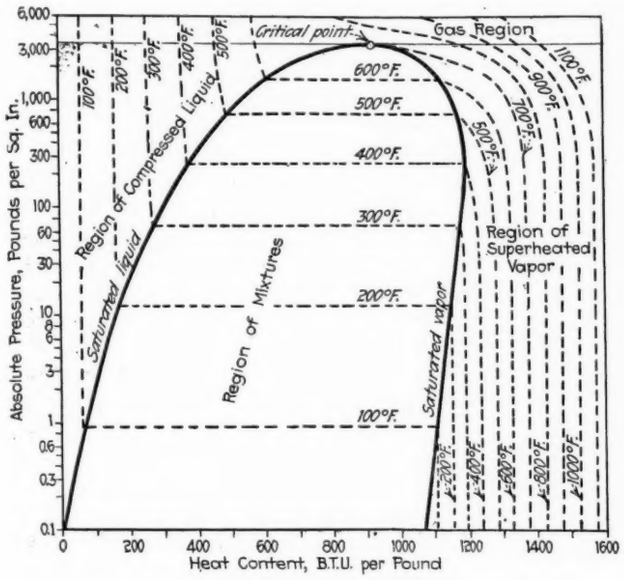
If we define saturated steam as steam containing all the heat that it can at that pressure without raising its temperature (superheating it), then it is clear that saturated steam cannot contain free moisture; that is, it must be dry steam, not superheated.

It is quite common, however, among engineering authorities to use the term "dry saturated steam." This expression at least intimates that saturated steam can also be wet. We can, therefore, say that either the foregoing definition is wrong or the word "dry," often coupled with saturated steam, is superfluous. Engineers are men of few words, and would not say "dry"

if they did not think it necessary. The evident conclusion is that many authorities do not accept the definition: "saturated with heat."

Among such authorities I might mention Kent, who defines saturated steam as "steam of the temperature due to its pressure—not superheated." He also says "Wet steam is steam containing intermingled moisture, mist or spray. It has the same temperature as dry, saturated steam of the same pressure." Evidently, these defintions show that he does not abide by the "saturated with heat" idea.

The same usage of the term was employed by Prof. J. W. Roe, formerly of Sheffield Scientific School, Yale University; R. H. Thurston, in his "Manual of the Steam Engine;" J. A. Moyer, in "Steam Turbines" and Professors E. C. Lucke (Columbia University) and J. J. Flather (University of Minnesota) in "Engineering Thermodynamics." Prof. E. M. Shealy (University of



Pressure-Total-heat Chart for Steam and Water, Showing Names for Various Conditions of the Fluid.

Wisconsin) in his book goes so far as to say that "saturated steam may be either dry or wet."

To agree with these authorities and many others that use the same terminology, the meaning of the term might be stated as follows: "Saturated steam is steam which, if heat is removed without change of pressure, will form free moisture." We may call this the "saturated with moisture" definition. This would mean that wet steam is also saturated, because removing heat at constant pressure will form free moisture, additional to what is already present.

In support of the "saturated with moisture" definition, we may refer to the use of the term "saturated air," which is clearly saturated with moisture and is generally defined as "air, which, if cooled at constant pressure, will precipitate free moisture."

On the other hand, I would like to mention at least two very good authorities whose use of the word "saturated steam" may be construed to uphold the "saturated with heat" definition; namely, Prof. L. S. Marks, of Harvard, and publications of the United States Bureau of Standards. Professor Marks speaks of saturated vapor and a mixture of vapor and liquid, but nowhere in his writings have I seen mention of "dry saturated vapor."

The wording employed in Circular No. 142 of the Bureau of Standards, "Tables of Thermodynamic Properties of Ammonia," is shown in the accompanying Mollier chart, which is clearly in accord with the "saturated with heat" definition. The term "Gas region" has been added for the area above the critical pressure.

Those who follow the "saturated with moisture" definition would use the term "dry saturated vapor" instead of "saturated vapor" in the diagram, and "region of saturation" instead of "region of mixtures." The term "saturated liquid," on this chart, can mean nothing else than "liquid saturated with heat," as it cannot mean "saturated with moisture."

It is evident that authorities differ and that anyone following either understanding of the word consistently is not open to severe criticism, as Mr. Peabody intimates. The question should, however, be settled so that a standard use of the word may be established. I hope that there may be an investigation of the original use of the word and finally a definite action of the engineering societies.

THOMAS M. GUNN.

New York City.

Why Not Ask the Manufacturer?

In the article entitled "Why Not Ask the Manufacturer?" in the Dec. 4, 1923, issue, the writer, E. C. Thomas, is unquestionably right in his statements as to the selection of the proper style of centrifugal pump for boiler feeding. However, in addition to the pump a great deal depends on the type of feed-water regulator used.

There are some regulators that, owing to their design, operate spasmodically and frequently have tightly closed valves at certain periods and at other times the reverse is true and the valves are wide open. Such feed-water regulators would produce exactly the result outlined by Mr. Thomas.

Had the boilers been equipped with regulators of the constant-flow type with the valves in the feed line proportioned for the evaporation and load requirements of the boilers, and in addition the water pressure differential drop across the valve, the conditions requiring the cutting out of the regulators would not have occurred. I had experience one time in a paper-mill plant where the conditions were similar to those cited by Mr. Thomas. The claim was made that regulators could not be used because the boiler-feed pumps, which were of the centrifugal type, could not be governed when the regulators opened and closed. The difficulty was not with the pumps or the governors; the entire trouble was due to the fact that the pumps were operating against a varying head, the regulators having either a tightly closed valve or a wide open valve. This was eliminated and the head made uniform by constant-flow type feed-water regulators. This plant is in operation today with entirely satisfactory service of not only the pumps but the feed-water regulators.

At light load it is essential that the feed flow to the boilers be controlled correctly without building up an excessive head on the feed pumps. This is what is accomplished by hand feeding in the plant cited by Mr. Thomas. The same results could be secured by the use of the proper type of regulator.

J. G. COPES.

Erie, Pa.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Relative Advantages of Bevel and Flat Seats for Safety Valves

What is the advantage of a bevel seat over a flat seat for a pop safety valve? *H. L.*

A valve with a bevel seat is more easily reground to make it tight than a flat-seated valve. But a beveled-seat valve is more likely to stick fast and for the same inside diameter of the valve seat, the relieving area of a valve with seat beveled 45 deg. to the spindle has a discharging capacity of only about 71 per cent as much as that of a flat valve with the same lift.

Furnace Volume for Pulverized Coal and for Fuel Oil

What furnace volumes are required for good results in burning powdered coal and for steam atomization of oil? *F. S. M.*

The furnace volume required for complete combustion depends on the physical and chemical composition of the fuel, the type of fuel-burning equipment, shape of the combustion chamber and means for mixing the fuel and air in the furnace. For burning pulverized coal high boiler efficiencies have been obtained when boilers are operated at 140 per cent rating when 0.85 lb. of fuel was burned per hour per cubic foot of furnace volume and for 236 per cent of rating 1.62 lb. was used per hour per cubic foot of furnace volume. With usual types of steam-atomizing burners, the quantity of oil burned should not exceed 3 or 4 lb. per hour per cubic foot of furnace volume.

Additional Pressure for Increased Temperature of Air

If a vertical cylinder containing air at a temperature of 40 deg. F. is fitted with a 6-in. diameter piston, and a load of 500 lb., including the weight of the piston, is required to keep the piston 18 in. from the bottom of the cylinder, how much load must be added so the piston will remain in the same position when the temperature of the air is 85 deg. F.? *A. W. W.*

As the volume of air would be the same, the pressure in each case would be directly as the absolute temperature. Therefore, if a load of 500 lb. is supported by the air at the temperature of 40 deg. F., or 40 + 460 = 500 deg. absolute, then for the temperature of 85 deg. F., or 460 + 85 = 545 deg. absolute, the pressure would be $\frac{545}{500}$ as much, or $\frac{45}{500}$ more than for the temperature of 40 deg. F. Hence, to hold the piston in the same position would require the addition of $\frac{45}{500}$ of 500 lb. = 45 lb.

Height for Water-Gage Glass of Return Tubular Boiler

How may it be determined whether or not the water-gage glass of a return-tubular boiler is placed at the proper level? *W. H. D.*

For a return-tubular boiler the lowest visible part of the water-gage glass should be 4 in. above the highest upper surface of any fire tube. The greatest height of the upper surface of any fire tube may be considered to be the greatest elevation of the upper part of any tube end where it projects through the front or the rear head of the boiler. Apply a builder's level first to the front and then to the rear head, to determine the greatest height of any tube end and, with a leveling board, extend the highest tube-end level of each head to a mark made on the water column or other stationary object near the place of the water-gage glass. Whichever may be the higher should be regarded as 4 in. lower than the elevation required for the lowest visible part of the water-gage glass.

Unreliability of Distorted Bourdon Gage Tube

If the cross-sectional form of a Bourdon gage tube is made rounder from freezing of water contained in the tube, would the gage give correct indications of pressure by correcting the gear rack lever or pointer hand to indicate 0 when there is no pressure on the gage? *W. P. W.*

Any permanent distortion of the cross-section or form of the tube results in variation in the amount and degree of uniformity of movement of the gage tube for given increases of pressure. The rounder the cross-section of the tube the less its movement for a given change of pressure, but the movements could not be relied upon as being in the same proportion as those obtained with a flatter cross-section of gage tube, and the old graduations should not be assumed to be correct for the changed conditions unless the spring can be "trained" by a competent gage maker to give correct readings when compared with a standard test gage.

Operating Alternator Without Direct-Current Excitation

Would it be possible to reduce the voltage on an alternating-current generator field to zero and still have the generator supply load? The generator is a 10,000-kw. unit and is the only one on the system. The load is made up of large synchronous motors which are running idle and with over-excited fields so that the system power factor is near zero leading. If the generator could supply this load without any current flowing through its field winding from the exciter, would it

make any difference if the field switch was opened or would it be better to have the field winding short-circuited through the exciter armature or through the discharge resistance? *R. J. K.*

If the system has sufficient condenser capacity, the alternating-current generator may be operated without any direct-current excitation. It will be necessary first to bring the generator up to voltage and put it on the system, and after the load has been connected to change gradually the power factor of the system to leading and, as the power factor is decreased, reduce the current through the field coils of the alternator to maintain the voltage constant on the system. After the current in the field coils has been reduced to zero, the field switch may be open-circuited and the generator will continue to carry load. However, after the field switch is open it will be necessary to maintain a constant condition in the system if stability of voltage is to be maintained. There is, apparently, no good reason for trying to operate such a system. Furthermore, it would be difficult to control the power factor so as to maintain constant voltage. If the field switch is left closed either through the exciter armature or through the discharge resistance, it will tend to stabilize the voltage of the alternator by opposing changes in the magnetic field of the alternator.

Boiler Plant Output per Pound of Fuel

We have two boiler houses in each of which the firing is with fuel oil. One house contains water-tube boilers operated under 160 lb. gage pressure with steam superheated 150 deg. and measurement is made of the feed water. The other house contains horizontal return-tubular boilers operated under 85 lb. gage pressure and saturated steam. The net output of the horizontal return-tubular boilers is measured by a steam-flow meter. In each case knowing the average temperature of feed water, amount of blowdown and percentage of steam used for pumps and oil burners, how can a fair comparison be made of net return per pound of fuel oil? *W. R. C.*

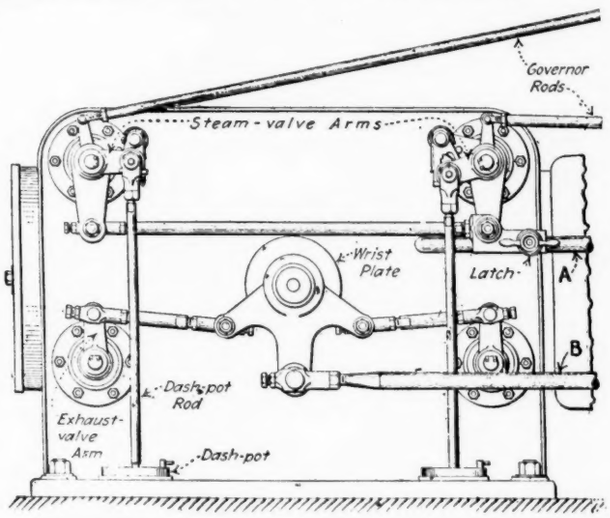
A fair comparison of over-all plant efficiency would be made on the basis of B.t.u. contained in steam actually delivered in excess of B.t.u. contained in the same weight of feed water from which the steam was generated. For the water-tube boilers, the total heat contained in a pound (weight) of steam delivered would be 1,279.1 B.t.u. above 32 deg. F. and the quantity of heat to be credited per pound of steam delivered would be (1,279.1 + 32) B.t.u. minus the temperature of the feed water. This multiplied by the actual weight of steam delivered by the plant, which would be the weight of feed water less blowdowns and weight of steam used by pumps and other boiler-house auxiliaries, would give the B.t.u. realized from the fuel; and dividing the result by the number of pounds of fuel oil would give the B.t.u. per pound of fuel oil.

In the case of the return-tubular boilers, the total heat of a pound (weight) of steam delivered would be 1,186.3 B.t.u., and the quantity of heat to be credited per pound of steam delivered would be (1,186.3 + 32) B.t.u. minus the temperature of the feed water. This, multiplied by the actual weight of steam delivered by the plant, which would be the weight of steam measured by the steam flow meter less any steam used by boiler-house auxiliaries included, would give the B.t.u. realized from the fuel; and dividing the result by the pounds of fuel oil used would give the B.t.u. per pound of fuel oil.

Greater Range of Cutoff with Double-Eccentric Engine

Why is a greater range of cutoff obtainable with a double-eccentric than with a single-eccentric Corliss engine. *W. B. F.*

In the ordinary single-eccentric Corliss engine all four valves are operated by a single wristplate, and unless cutoff takes place before the wristplate swings farthest to one side of its central position, it will not take place during the stroke of the piston. Hence if the eccentric is set 90 deg. ahead of the crank and the wristplate is in central position at the beginning of the stroke, the wristplate would be carried to the limit of its travel for about 90 deg. rotation of the engine shaft, or about one-half stroke, and that would be the maximum cutoff. In order to obtain release after expansion before the end of the stroke and compression by closure



A type of valve connections for double eccentric Corliss engines

of the exhaust valves before the end of an exhaust stroke, an eccentric that operates exhaust valves must be set more than 90 deg. ahead of the crank. This causes the wristplate to be past its central position in the beginning of a stroke, and if the steam valves are operated by the same eccentric and wristplate, they must have lap when the wristplate is in central position or they will have too much lead; and as from advancing the eccentric the wristplate will reach its farthest swing to one side earlier in the stroke, the range of cutoff is reduced to less than one-half stroke.

In a double-eccentric Corliss engine the steam valves and exhaust valves are operated by separate eccentrics and consequently the desired action of the exhaust valves for release and compression can be obtained by setting the exhaust eccentric without interfering with the operation of the steam valves. In the figure the steam-valve arms are shown connected to the steam reach rod *A*. This is operated from a steam eccentric rod, and the exhaust valves are connected from a wristplate driven from a point below the wristplate hub by an independent reach rod *B* that is connected with a rocker moved by the exhaust eccentric rod. Independent setting of the steam eccentric may thus permit of increasing the range of cutoff considerably beyond haif stroke without interfering with operation of the exhaust valves.

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

The "Log" Scale

THE articles on single-line diagrams in the Feb. 26 and March 4 issues showed how to lay out a pair of scales on the two sides of a straight line to make a diagram showing the relation between quantities that depend on each other and on nothing else.

For such diagrams it is often convenient to have a scale that can be read to the same degree of accuracy (expressed in per cent) in all parts. This type of scale is already in existence and is used extensively in the construction of slide rules. It is called the logarithmic scale, or the "log" scale for short. Such a scale running from 1 to 10 is shown in Fig. 1. Other log scales can be constructed with any desired distance between 1 and 10, but the relative sizes of the various spacings must remain as shown. The part shown in Fig. 1 might be called one section of a "log" scale. To get another section, it is merely necessary to place another like the first at the right or left.

Fig. 2 shows a log scale with two sections, each half as large as that in Fig. 1. It will be noted that the divisions in the right-hand section are given values ten times as great as the corresponding divisions of the left-hand section. This is true for all log scales.

Log scales have some remarkable properties which can best be shown by actual examples. Suppose, first, that it is desired to make another diagram for the problem already considered in the March 4 issue, namely, for turning pounds of water into U. S. gallons or vice versa. Imagine the upper and lower scales of Fig. 1 cut apart. Shift the decimal point in the upper scale so that the divisions run from 0.1 to 1. Label this scale "U.S.Gallons" and the lower scale "Pounds of Water." These two scales can be placed together at random in any position, and the corresponding readings will bear a constant ratio to each other. We know that one gallon must equal 8⅓ lb. Match the scales at these points, pasting them permanently in this position. Then the diagram will read correctly at all points. To fill in the sections where the scales overlap, necessary parts of the two scales are repeated in the upper-right and lower-left portions. The completed diagram is shown in Fig. 3.

Log scales are even more convenient where one of the quantities varies as the square of the other. In such cases, however, the two log scales cannot have sections of the same size. In fact, if one quantity varies as the square of the other, one log scale must have sections twice the size of the other. This can be illustrated by constructing a diagram for numbers and their squares. If the scale for the numbers corresponds to Fig. 1, that for their squares must correspond to Fig. 2.

The only question left to decide is the relative position of the two scales. This can easily be settled by noting that the square of 1 is 1, and the square of 10 is 100. The scales have been placed in their proper relative positions in Fig. 4. This diagram shows that the square of 3 is 9, the square of 7 is 49, the square root of 25 is 5, the square root of 50 is 7.07, etc.

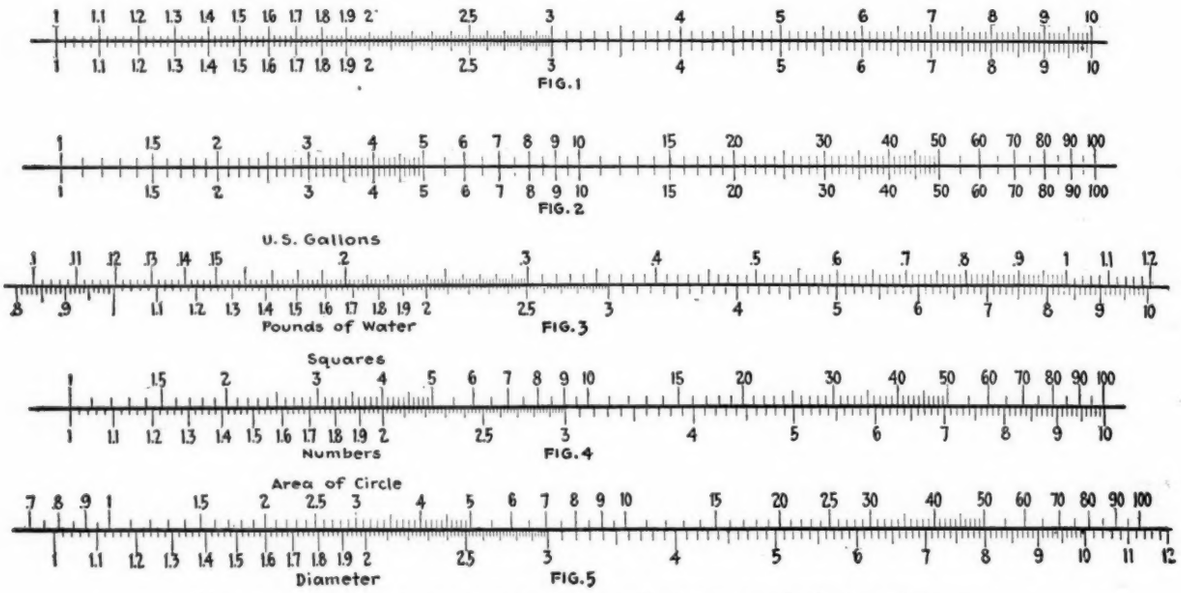
In this particular case one quantity is the exact square of the other. The same two scales, but in different relative position, can be used for any case where one quantity is proportional to the square of the other.

In every such case a diagram can be constructed by cutting apart the two scales of Fig. 4 and pasting them together in the proper relative position.

For example, suppose it is desired to make a diagram showing the relation between the areas of circles and their diameters in inches. Separate the two halves of Fig. 4 with a pair of shears in the manner already described. Cross out the word "Squares" on the upper scale and write instead "Area of Circle." Cross out the word "Number," on the lower scale and write "Diameter." Then slide the lower scale to the left until diameter 10 comes opposite area 78.5.

If the scales are now pasted permanently in this position, the diagram is correct for turning diameters into areas or vice versa. This must be true because the area of a 10-in. circle is known to be 78.5 in., and if the positions of the scale are right for this case they must be right for all others.

Adding the necessary portion of another section to the right of the lower scale and the left of the upper scale, we have Fig. 5. In Fig. 5 it is important to note how the added portions are numbered.



Figs. 1 to 5—"Log" scales and their applications to single-line diagrams

Heat Transfer Through Turbulent Gas Flow*

By LOYD R. STOWE

In heat absorption by contact the big factor is dispersing the heat equally through the gas itself by stimulating turbulence of flow through increased velocity or other means. To arrange that the entire body of the gas flows adjacent to the surface, the use of small gas streams, and a minimum number of such streams, is recommended.

THE shorter the length of time that the combustion gases are under the cooling influence of an economizer or the last passes of a boiler, the greater will be the amount of heat given off. If this fact can be substantiated, the biggest stumbling block to a proper analysis of heat transfer will have been removed.

If a definite amount of gas-cooling surface is to be shaped into an economizer and some definite average gas velocity is employed, this velocity will fix the total cross-sectional area of gas flow, so that if it is decided to use small unit gas streams a great number of them will be required.

Next, it will be discovered that per foot of length it takes more heating surface to bound a large number of small streams than is required to surround a smaller number of large streams having the same total cross-sectional area.

Considering a total cross-sectional area of gas flow, considerably more surface is encountered per foot of gas travel with the small streams than with the larger ones. And since the use of some definite amount of heating surface is being considered, it is evident that the total feet of gas travel through the apparatus will be much shorter with the small streams than with the large ones. With the same velocities in both instances, it is therefore apparent that a particle of gas will remain under the cooling influence of the boiler or economizer a shorter length of time when small unit gas streams are used.

Gas flow in either parallel-flow or cross-flow water-tube boilers or economizers can be divided into unit gas streams with their bounding surfaces and unit areas measured. Fire tubes lend themselves best to a simple analysis of the subject at hand and will be used, although whatever deductions are made from the use of fire tubes may be reached for water tubes by parallel analysis.

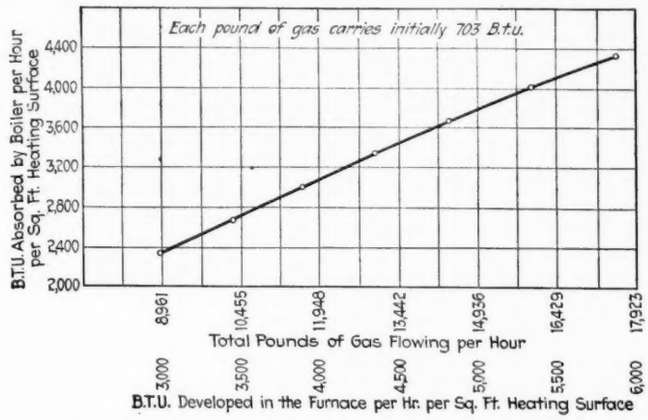
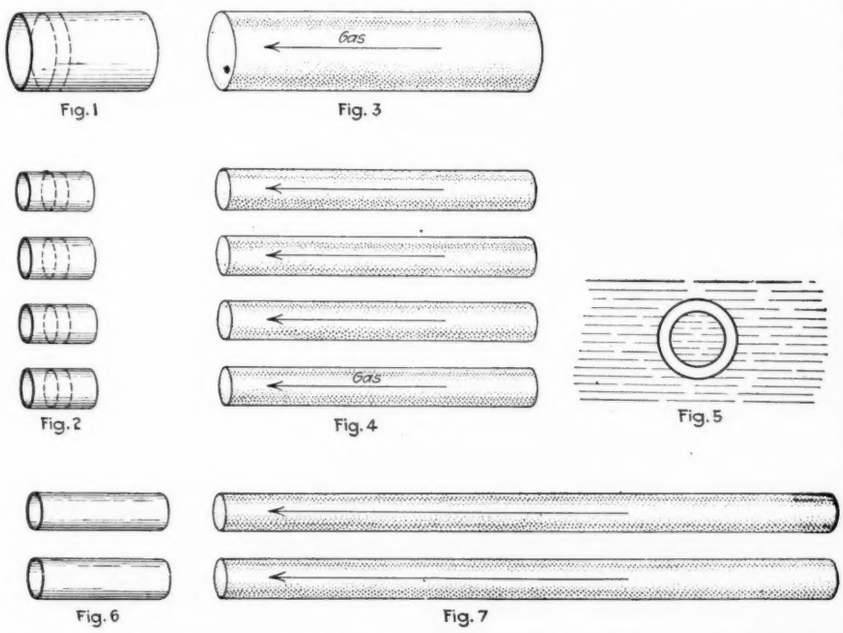


Fig. 8—Illustrating effect of turbulence, produced by increased velocities, upon total heat transfer



Figs. 1 to 7—Illustrating effect of surface arrangement on heat transfer

Fig. 2 gives the same heating surface as Fig. 1, the same cross-sectional area and the same gas velocity, but only one-half the time of contact. Turbulence makes the arrangement of Fig. 2 more effective than Fig. 1. The arrangement of Fig. 6 has the same heating surface with half the cross-sectional area and twice the gas velocity. This further improves the heat transfer, but increases the draft requirements.

The reasoning does not apply to the first bank of tubes where furnace temperatures are above, say, 2,000 deg. F., for the boiler surfaces abutting the furnace or otherwise encountered by flame do not receive their heat primarily through contact with the gases, and consequently the considerations of turbulent flow as a means of heat transfer do not apply. Such surfaces should be arranged to sustain combustion. So far as arrangement is concerned, these surfaces have nothing in common with the final passes of a boiler and in the matter of tube spacing should differ materially from them.

Let Figs. 1 and 2 symbolize two fire-tube boilers. Each of these has the same total heating surface and the same total cross-sectional area, and consequently the same gas velocities, but owing to a difference in ratio of periphery to gas area, a shorter gas travel prevails with the use of the small tubes. Since the velocities are the same, a particle of gas will pass through the boiler with small tubes in less time than will be required for the boiler having the larger unit gas streams.

With all other conditions the same, the length of time that a particle of hot gas is subject to a cooling influence is a factor in determining the amount of heat given off, so if the opening statement is correct, with a change in the time element, there must be a change in some other conditions that compensates for the shorter time.

There is a change of two conditions—a purely geometric one that exactly compensates for the shortening of the time element, and a change in the turbulence of gas flow that in the matter of heat transfer is favorable to the use of smaller unit gas streams.

*Abstract of a paper read before Chicago Section, A.S.M.E., Jan. 15, 1924.

Applying demensions to Figs. 1 and 2, four 2-in. tubes have the same cross-sectional area as one 4-in. tube, but the periphery of the two equal areas is twice as great with the 2-in. tubes. For equal total surfaces the 2-in. tubes must be only half as long as the 4-in. ones.

In Figs. 1 and 2 the gas confined between the two parallel planes represented by the dotted rings are equal masses. It will be seen that the total area of contact of the unit of Fig. 2 is twice that of Fig. 1, but that the time element is cut in two. During the interval of time that the unit mass of Fig. 2 comes into contact with all the cooling surface, the unit of Fig. 1 encounters only half as much surface, so it must continue for another like interval to encounter all the cooling surface.

To demonstrate the effectiveness of turbulence, take much larger units of gas mass, as for instance, the quantity of gas that flows through either the boilers of Figs. 1 or 2 in an hour's time. Figs. 3 and 4 represent such units. Because of like cross-sectional areas both their lengths and their average linear velocities are the same. Let the gas streams of Figs. 3 and 4 be threaded through their respective boilers of Figs. 1 and 2. Bear in mind that the total gas mass and the total amount of heat carried is the same in both cases.

While the gas is under the cooling influence of the boiler, assume that at successive cross-sections of the streams of Fig. 4 the heat is diffused equally to all points, so that the temperature of the surface of the streams at any section is as high as the temperature at the core or center of the stream, but that in Fig. 3 the heat is confined more to the center of the core with but a small amount carried to the outer surface of the stream. The result will be that as these equal quantities of heat carried in equal volume of gas are threaded through their respective boilers, the temperatures along the gas side of the plate generally will be higher with Fig. 2 than with Fig. 1 and the rate of heat transfer higher, resulting in a higher efficiency. At the same time the reasoning suggests that small gas streams may be advisable and emphasizes the importance of turbulence.

Importance of Turbulence

To improve heat absorption, the problem is not so much one of transferring heat from the gas to the tube as one of dispersing heat equally through the gas itself. Dispersing this heat by the convection of gases as induced by a difference in their densities or by the conduction of heat through gases is too slow, being a matter of minutes rather than the fraction of a second available. To disperse the heat through the cross-sections with sufficient rapidity, it must be carried about on the turbulence of flow, and the problem in design is to stimulate this turbulence and increase its effectiveness.

Two definite things known about gas flow and turbulence are, first, that the linear velocities of gas flow are higher in the center or core of the stream than the velocities adjacent to the walls of the stream, and second that an increase in average linear velocities increases the effectiveness of turbulence. Fig. 8 represents a vast extent of actual data and shows that with unchanging initial temperatures the rate of heat absorption increases with the linear velocities of the gas.

Reasoning leading to this conclusion is as follows: As the velocity of the gas changes, the character of the gas streams remains unchanged and consequently the area of contact of a unit mass of gas remains unchanged. The total extent of the heating surface and the initial temperatures remain unchanged, so there is nothing to compensate for the shortening of the time element, but increased turbulence due to higher velocities.

Applying these two proven facts to the boiler of Fig. 1, it will be evident that the velocities at the core of the tube are higher than the average linear velocity and that the velocities adjacent to the surface are lower than the average linear velocity. If the core is removed by the use of a concentric inner water tube, as in Fig. 5, and a greater number of these annular gas units are used, so that the average linear velocity will not be increased, it will be evident that the velocity in the annular ring adjacent to the tube over that prevailing in the same area of Fig. 1 has been increased from something below the average linear velocity up to the full average linear velocity. This increase in velocity adjacent to the heating surface will increase the effectiveness of the turbulence and increase the rate of heat transfer. The object is to get the flow of gas near to the surface to liven up turbulent conditions adjacent to the surface.

A simpler construction than Fig. 5 can be employed. For instance, the average distance of the gas from the surface is as short in Fig. 2 as it is in Fig. 5.

First Rule of Heat Transfer

The first rule for efficient heat transfer by contact is then: Arrange that the entire body of the gas flows intimately adjacent to the surface. Thus the smaller streams of Fig. 2 are more economical than those of Fig. 1 and the opening statement that a reduction in the time element accompanies increased efficiencies of transfer is sustained.

Up to this point higher average gas velocities have not been considered. In Fig. 2 the total area may be generous, meaning a relatively slow average gas velocity. By using a less number of tubes of the same diameter (see Fig. 6), the total gas area is decreased and the average gas velocity and the turbulence of the flow increased. From the foregoing it will be appreciated that this increases the effectiveness of the apparatus.

To preserve the total amount of heating surface, it is necessary, when reducing the number of tubes, to increase their length. Thus it is seen that the length of gas travel is only incidental to the crucial features of design.

In the foregoing two simple yet comprehensive rules have been developed:

1. Arrange that all the gas flows close to the tubes, through the use of small gas streams.
2. Use the minimum number of such streams.

The first rule does not entail any increase in power required to drive the gases through the apparatus, for this tendency does not increase velocity. As the size of unit streams decreases, their numbers increase to preserve the same gas area, and the length of the gas travel decreases. There is no material increase in draft losses here. This tendency, consequently, should be fully utilized first.

The thing that imposes a definite limitation on the effort toward small streams is the necessity for entirely adequate facilities for keeping the gas surfaces free of soot, dust and slag.

The other rule of course means an increase in draft losses. The limit of fewer streams is reached when the added cost of power to drive the gases through the boiler begins to equal the value of the additional heat reclaimed.

Conclusions Summarized

Whether or not the limit of close nesting of tubes has been reached is a question. The following summary may be deduced from the foregoing:

1. As much heat as possible should be absorbed by radiation to the tubes about the fire where no expenditure of draft power is required.
2. Excellent combustion conditions involving long flame travel and the reduction of the temperature of fly ash below the fusing point in the "radiation" bank should be in evidence that the tubes may be brought closer together without courting cleaning difficulties.
3. With clean gas and no cleaning difficulties an ideal heat exchanger would be somewhat like the automobile radiator—a next to infinite number of small streams and short gas travel, and incidentally with an extreme reduction in the time element.
4. Under the less ideal conditions existing with which the chief concern is with the gas flow, the diameter of water tubes is of no particular significance so far as heat transfer is concerned.
5. Having once reached the limit of small gas streams, any further increase in the effectiveness of surface is purchased at a price of increased power required to drive the gases through the boiler.

Patent Office Needs One Hundred Assistants

The Patent Office is in need of 100 additional assistant patent examiners and the Civil Service Commission will hold examinations on April 9 and later dates for these positions. The entrance salary, effective July 1, is $1,860 a year, and increases are provided up to $5,000 a year. The examination comprises mathematics, technics, physics, interpretation of mechanical drawings, French and German, and some branches of engineering. Both men and women are admitted. Full information may be obtained from the United States Civil Service, Washington, D. C., or the secretary of the Civil Service Board at the post office or customhouse in any city.

Elimination of Waste in Fuel Has Become a Great Factor in Coal Industry

Economy Shown in Gas and Coke Industry—Enormous Use of Petroleum —Hydro-Electric Development—All Show Changing Conditions in Coal Industry

THE THREE year contract between the coal operators and miners is regarded in Washington as a decided step forward. The situation has brought with it a demand that the industry should keep watch on the rate of its own expansion. Current basic information with regard to the opening of new mines is needed.

It is believed that in normal times comparatively few new mines would be opened if the total amount of expansion in progress were known. Even under present prospects, when many relatively low-cost operations are facing an uncertain future, it is known that new mines are being opened and that many other new mines are in prospect.

With the situation that now impends, there is new reason for information in regard to new mines to be generally available. Production has proceeded for a long period without interruption. Stocks are large and three years of peace stretch ahead. In addition the country's consumption of coal is not increasing at the same rate maintained during the twenty years preceding 1919. The higher coal prices which have prevailed over a period of seven years have turned the attention of the consumer to economies in the use of coal. It formerly was so cheap that there was no incentive to attempt to eliminate waste. The elimination of waste in fuel, however, now has reached the point where it is almost the rage. Material economies have been effected. The Geological Survey reports show, for instance, that during the last five years there has been a reduction of 25 per cent in the amount of coal necessary to produce a kilowatt-hour. The coke industry has gone from a beehive to a byproduct basis. The gas that once was wasted is now being burned under boilers and in furnaces. The International Railroad Fuel Association points to some very striking savings in the increased number of locomotive miles attained. A great wave of hydro-electric development is under way. The enormous production of petroleum has a deeper significance than the actual coal displaced by fuel oil. It has curtailed a large amount of new business, which would have come to the coal companies. An example is the retarding of electric line development, due to the use of the automobile. The bunker business is rapidly being lost.

All of these things taken together have resulted in a decided flattening of the curve, indicating the average rate of increase in coal consumption.

Big Generator Ordered for Japan

A single-unit turbine generator has been ordered from the International General Electric Co. by Mitsui & Co., for the Toho Electric Power Co. of Japan.

This G-E Curtis turbine has a capacity of 50,000 hp. and will drive a generator that will supply 35,000 kw. of electric current at 11,000 volts, enough to light 1,000,000 of the average Japanese homes. With the exception of the rotor, the machine will be disassembled for shipment. The revolving field of the generator, which is 27 ft. long and 4 ft. in diameter, will be made from a single forging and will weigh about fifty tons. This will turn at a speed of 1,800 r.p.m.

This order, including accessories and switchboard equipment, represents an initial capital expenditure of more than $1,000,000. The new unit will be located in the city of Nagoya.

Holtwood 150,000-Hp. Power House Nearing Completion

On Saturday, March 1, the Baltimore and Philadelphia sections of the American Institute of Electrical Engineers, and the Baltimore section of the American Society of Mechanical Engineers, held a joint meeting at Holtwood, Pa., at which about 150 were in attendance. One of the purposes of the meeting was to give the members of these sections an opportunity to inspect the hydro-electric plant of the Pennsylvania Water & Power Co., which is nearing completion. The program consisted of a meeting in the morning, a luncheon in the clubhouse at which the company was the host, and inspection of the power house in the afternoon. A paper by N. B. Higgins and R. L. Thomas, covered the history, general features and electrical design of the Holtwood development with particular reference to the new extension. F. H. Rogers presented a paper on the hydraulic machinery in the plant, dealing with the progress that has been made in turbine and draft-tube design since the first units were installed in Holtwood. J. Walter May read a paper on the construction features of the new extension, which is to contain two 20,000-hp. units; one is now in operation, and the other will be ready to go into service about the first of April.

The Holtwood development is situated on the Susquehanna River about 25 miles from its mouth. In October, 1910, the first unit in this plant went into service. This machine was rated at 13,500 hp. under 55 ft. head, as were the four other units that comprised the first installation. Since that time units have been added until the plant now has a total capacity of 150,000 hp., making it the largest south of Niagara Falls and east of the Mississippi. The first eight units installed generate 25-cycle current; the two now being installed are 60-cycle machines. Frequency changers are provided to tie the two systems together. An article on this development is in preparation and will appear at an early date in *Power*.

Great Falls Bill Reported Out of D. C. Senate Committee

The Senate Committee on the District of Columbia has reported favorably a bill authorizing and directing the Secretary of War to construct all the dams and other necessary works for the development of hydro-electric power at Great Falls on the Potomac River. The bill provides that these structures are to be erected in accordance with and subject to the limitations of the report made by Major M. C. Tyler, of the Corps of Engineers.

The bill provides further that the Federal Power Commission is authorized to make such modifications in Major Tyler's plans as it may find necessary to increase the maximum amount of the hydro-electric energy which may be developed at Great Falls.

The committee in reporting the bill to the Senate points out that a similar measure has passed the Senate during two previous Congresses, and expresses the earnest hope that this bill will become a law at the present session.

The Commissioners of the District of Columbia, in reporting on the bill, recommend its passage but attention is called to the fact that so long as the public utility companies of the District of Columbia are required to maintain their own steam plants as a reserve, the saving to them of procuring a part of their power from Great Falls will not be great. In that connection the commissioners call attention to the fact that the Potomac Electric Power Co. maintains a steam plant which they estimate to be worth $6,000,000 without including the value of the land

which the plant occupies. The plant on Dec. 31 had a capacity of 98,000 kw. An additional 20,000 kw. unit is under construction, however. It will be completed in October.

The development recommended by Major Tyler will cost $44,421,000, he estimates. The estimated cost is made up as follows:

1. A dam and power generating station at the District of Columbia line (Chain Bridge), estimated to cost	$13,600,000
2. A dam and power-generating station at the Great Falls	18,616,000
3. Three storage reservoirs at the following locations:	
a. Great Capacon River, W. Va. near its mouth	2,340,000
b. North fork of the Shenandoah River at Brocks Gap, near Broadway, Va.	3,615,000
c. South branch of the Potomac River, about one-half mile up stream from its mouth near Green Springs, W. Va.	6,250,000
Total cost	$44,421,000

Peak Loads Increase 30 Per Cent in 1923

The Southern California Edison Co. has recently made studies to ascertain the peak load of its system. The system demand factor for 1923 was 46.2 per cent and the system load factor was 56.8 per cent. The system peak of 312,500 kw., which occurred on Oct. 17, 1923, amounted to an increase of 30 per cent over the system load of 1922. This growth was partly made up of the steady increase in the peaks of all the districts, some of which have had a very remarkable development. The metropolitan area of Long Beach district now has a peak greater than the total system peak of twenty years ago.

The Engineer's Contribution to the Community

One of the most interesting meetings of the season was the consensus of opinion of those attending the dinner gathering on civic affairs held by the Chicago Section of the American Society of Mechanical Engineers on Wednesday evening, Feb. 27, at the City Club. Mayor Dever and Calvin W. Rice, secretary of the society were the speakers. During the meal the diners were entertained by the Detrick orchestra, the LaSalle Extension University quartette and community singing.

As an introduction to an interesting illustrated talk on his South American trip with the American contingent to the International Engineering Congress, in which he brought out the South American love of beauty and the artistic, as well as the engineering features of the countries passed through and the prominence given to engineers in these countries, Secretary Rice emphasized the importance of developing in the engineer the international mind, having at heart the welfare of all mankind and the world-serving spirit that will be necessary to bring order out of chaos. The first obligation of the engineer was to be useful in the community. Nowhere was the influence of the engineer and the sound business man more needed than in municipal affairs, and it was in this field that the engineer, of all persons, was best qualified to serve. The starting place, then, is service to the community which should exert its influence on the state and in turn, the state on the nation in helping to solve world troubles and obviate the general disaster impending.

In the future the engineer must take a broader, stronger place in world affairs. To this end the curriculum of engineering education is being revamped to give a better and broader foundation to the student. The various educational institutions of the country are realizing the fallacy of turning out engineers like machines.

The real issue in the world today is what the United States is going to do to help alleviate world troubles. Each man, and particularly each engineer, must contribute his influence to the community and so on through the nation to see that something really is done. A beginning already has been made. In almost every city engineers are doing something to help community life. The coming World Power Conference should have a tremendous influence on the welfare of the world and an engineering contribution which should result to the benefit of Czechoslovakia is the proposed conference on the Science of Management, to be held shortly in that country.

Mayor Dever recognized the importance of the engineer in solving the many intricate problems now pressing for solution in the city. He reviewed briefly the difficulties they were having in budget making and the need for entire reorganization of the various city departments. He invited the engineers to step in and create an organization that would function properly. Their services also would be appreciated in helping to draw up scientific, business-like methods for preparing estimates of expenditures. The city was now in arrears $33,000,000 to complete the various improvements for which bond issues had been voted in the last two or three years. In every case the cost had been at least double the estimate. The Mayor outlined briefly the status of these various improvements, a typical example being the enlargement of South Water Street, for which $5,000,000 had been appropriated, $3,000,000 spent and nothing actually accomplished in physical construction. To complete the work as planned, it would need $20,000,000. The railway terminal problem, the traction problem and the subway were all engineering problems to which the engineering organizations of the city could contribute and their services at any time would be appreciated; in fact, Chicago's great future depended upon what use could be made of the engineering skill available in the city and its welfare upon how wisely this engineering skill was used in the development of Chicago's problems.

Muscle Shoals Hearings Are Uninteresting

DURING the ten hours of debate in the House on the McKenzie bill directing the Secretary of War to accept Henry Ford's offer for the Muscle Shoals properties of the government, great lack of interest in the debate was manifested. The attendance at all times was small. This was taken to mean that members long since had made up their minds how they would vote on this bill. Most of the speeches quite evidently were made for the *Record*.

Representative Burton, of Ohio, is generally conceded to have presented the most effective debate against the bill. He opposed it principally because it involves a radical departure from the established policy of the government with respect to the control of the use of water power.

A bill authorizing the Secretary of War to lease Muscle Shoals to a group of New York men, Elon H. Hooker, A. H. Hooker, J. G. White of the White Engineering Corp., and W. Waterbury, vice-president of the Pennsylvania Railroad, was introduced by Senator Wadsworth of New York.

The newest offer stipulates, besides other items, that the term of the lease would be only fifty years and the government would retain control of the stock of the corporation to be formed.

Tailrace Tunnel Planned for Niagara Gorge

The Lower Niagara River Power & Water Supply Co. has filed with the Federal Power Commission its application for license covering its proposed project in Niagara Gorge. This application is in pursuance of the terms of the preliminary permit issued to this company March 3, 1921.

In its application for license, the company quotes sections from the special act passed in 1902 by the New York legislature giving it the authority to carry out this development. It also cites the New York water power act of 1921 and 1922 in support of its contention that it is qualified with the necessary state rights to secure a license from the Federal Power Commission.

The plans submitted by the Lower Niagara Co. with its application for license provide for the utilization of 74 ft. of the drop in the gorge. The plan specifies a maximum diversion of 40,000 cu.ft. per sec. on a load factor of 48.8 per cent, or an average daily diversion of 19,500 cu.ft. per sec. This is the full amount of the water diverted passed the Falls by the Niagara Falls Power Company.

The point of diversion is specified as being at the lower end of the Maid of the Mist pool, and the plan calls for the location of the power house at that point. A tailrace tunnel 51 ft. in diameter is specified in the plan. The outlet of the tunnel is two miles distant, near Devils Whirpool. The company plans to install 33,600-kva. units operating on 60 cycles.

The plan contains no explanation as to why only 74 ft. of the fall in the gorge section of the river is being utilized. The total drop is 90 ft. In that connection the point is made that at least 85 ft. of that total should be

utilized. The tailrace tunnel is by far the largest that ever has been undertaken. Another interesting feature is operation on 60 cycles. Practically all power in the Niagara region is operated on 25 cycles.

The New York Water Power Commission takes the view that the Lower Niagara Co. must get a special permit from it before undertaking the construction of the project. The fact that the company has made an application to the New York Commission for such a permit is an indication that it recognizes the need for such authority. No action on that application has been taken by the New York Commission.

Workers' Contribution to Industry Recognized

At the various plants of the General Electric Co. a few days ago workmen gathered about a platform, and the works manager called a few of their number forward and presented them with a sum of money and a certificate acknowledging their contribution to the progress of the electrical industry.

These awards, comparable to the honors conferred upon engineers by electrical societies, were made by the Charles A. Coffin Foundation, which was established for the broad purpose of stimulating progress and public service in all branches of the electrical industry—public utilities, electric railways, among graduate students doing research work, and finally among employees.

So far as is known, this is the first time that employees in any large industry, particularly workers in the shops, have been publicly recognized for work they have done for the industry outside their ordinary duties.

Awards were made to forty-eight; sixteen to engineers, six to commercial men and one woman, ten to formen, ten to shop workers and five to administrative employees. There was keen competition among the factory managers to obtain representation for their men on the list, and the result of the new method of recognizing ability will be watched during the coming year.

Sioux City Constructing Its New Plant

The Sioux City Gas & Electric Co., which had temporarily postponed the construction of a large generating station on the Big Sioux River, is now ready to proceed with the undertaking, according to W. J. Bertke, general manager. It will cost in the neighborhood of $3,500,000 and will furnish energy not only for Sioux City, but for more than a hundred smaller places in Iowa, Nebraska and South Dakota. The equipment will consist of two 11,250-kw. turbines with the necessary boilers and auxiliaries. The station will have an ultimate capacity of at least 90,000 hp. The furnaces will burn low-grade pulverized Iowa coal. Other features of the equipment include devices to absorb the heat that usually escapes up the stacks, electric motors to drive the small auxiliary apparatus and a special treatment of the river water to make it suitable for boiler purposes.

Canal from Lake Erie to St. Lawrence River Proposed

According to a United States government report it has been officially announced that application will be made to Parliament for an act to incorporate a company under the name of Federation Canal & Power Co., with a capital of $500,000,000, for the purpose of acquiring the assets and liabilities of the Transportation & Power Corp. (Ltd.), which was incorporated in 1906, and to construct and operate a combined canal and ship channel or deep waterway from a point below Montreal to the head of the Great Lakes, the depth to be 35 ft. and of sufficient width to permit ocean vessels to pass at reasonable speed at any point.

World Power Conference Tours and Transportation

Thomas Cook & Sons, 585 Fifth Ave., New York City, the official transportation agents of the World Power Conference, London, June 30-July 12, have just issued a booklet on travel arrangements. The tours arranged are twelve in number and range from the simple trip to and from the Conference which will be $525, up to elaborate pleasure tours to the Mediterranean amounting to $1,485. Trips are also arranged to fly from London to Paris, Brussels and Amsterdam. Full information as to dates, type of transportation, baggage, hotel accommodations, fees and tips as well as a list of return sailings from Aug. 1 to Sept. 20, is included in the booklet.

Diesel Engines Reduce Fuel Consumption

Conversion from steam propulsion to Diesel drive has reduced the fuel consumption at sea of the M. S. "Seekonk" three-fourths while the conversion of her deck machinery and other auxiliaries shows a further saving in port of nine-tenths the fuel oil formerly consumed, according to the official figures just made public by William Cramp & Sons covering the vessel's 13,322-mile maiden voyage as a motorship along the Atlantic and Pacific coasts. The cruise from New York City to Tacoma, Wash., and return was made without stop except in ports and going through the Panama Canal. The time consumed was 84 days, of which 51 were at sea, 29 in port and four running in harbors and rivers. A mean sea speed of 10.29 knots was maintained and on completion of the voyage no repairs or replacements of any part of the main or auxiliary machinery were required.

These figures, which are believed to have established a record, are that motorships are now available.

The "Seekonk" is a former Hog Island steamship. She was purchased from the United States Shipping Board and converted by the company by substituting Diesel engines for the oil-burning steam-turbine drive, the cruising radius was increased from 8,000 to more than 36,000 miles with the same oil bunker capacity. By cutting the disparity in operating costs, which now weigh so heavily against the American ships in competition with foreign merchantmen, these economies are believed to be more than sufficient to bring into active service scores of vessels now rusting away in American harbors.

Executive Committee Selected for Heat Transmission Study

The National Research Council, which has been requested to undertake an investigation in Heat Transmission, outlined in Feb. 5 *Power*, page 233, has selected an executive committee consisting of:

F. Paul Anderson, director, Research Laboratory of the A. S. H. & V. E.; W. L. Badger, University of Michigan; W. H. Carrier, president Carrier Engineering Corp.; Harvey N. Davis, Harvard University; H. C. Dickinson, Bureau of Standards; H. Harrison, Brunswick-Kroeschell Co.; F. E. Mathews, consulting mechanical engineer; George A. Orrok, consulting engineer; T. S. Taylor, physicist, Westinghouse Electric & Mfg. Co.

A meeting of this committee will be held in the near future and the necessary steps taken to launch the project.

Detroit New Power Station Agreed Upon

After many conferences, beginning in May, 1923, the plans for the construction of a power station for the City of Detroit, at the foot of Morrell St., with 20,000 kw. turbo units, have been finally agreed upon by all interested parties. The only change from the original plans is, that, at first, three 20,000-kw. turbines only will be installed.

The Detroit Edison Co. offered to cancel the contract under which power has been furnished, and which was to be extended until the completion of the new plant; and proposed a new contract at a lower rate, if the term of the contract with the Detroit Edison Co. was extended to Dec. 31, 1929. Such extension of the term of the contract will permit the Detroit Edison Co. to utilize the investment, made for furnishing service to the Detroit street railway, to better advantage at the final expiration of the contract. Under the proposed contract the power to be furnished by the Detroit Edison Co. is limited, when the new city plant shall be ready for operation, so that two 20,000-kw. turbines in the city plant may be operated at practically capacity load. January, 1928, the power to be furnished by the Detroit Edison Co. will be reduced by one-third, and January, 1929, by another third. Thus during the last year of the contract the Detroit Edison Co. will supply a demand of approximately 8,000 kw. only.

According to the terms of the contract, now in force, rates to be paid for power by the Department of Street Railways to the Detroit Edison Co. would have been increased to July 1, 1924. The waiver of this increase will save, to the Department of Street Railways, an amount that warrants the extension of the term during which the Detroit Edison Co. shall supply a part of the required service, according to the Bulletin of the Associated Technical Societies of Detroit.

Wabash River Plant Ready

The American Public Utilities Co., which is building near Terre Haute, Ind., the superpower plant for the Indiana Electric Corp. and the Central Indiana Power Co., announces that it is about ready to start the operation of the first 20,000-kw. steam turbo-generator and expects to have the second unit of the same size in operation by April 1. The third unit will be installed during the present calendar year, if it proves possible for the manufacturers to complete construction and make shipment by that time. The fourth 20,000-kw. unit will probably have to be installed next year, and the last one of the same size not later than the early part of the following year. This will provide 100,000 kw. capacity at the Wabash River plant, in addition to the seventeen or eighteen other plants of the Central Indiana Power Co. scattered over the territory served. The station, which will burn coal mined on the spot, will operate on 2 lb. per kilowatt-hour.

Society Affairs

The Hartford Engineers' Club will hear S. Ferguson speak on "Manufacture and Distribution of Hydro-Electric Power," at the general meeting to be held on March 18.

The Providence Sections of the American Chemical Society and American Society for Steel Treating at a joint session will hear General F. C. Dickson, Commanding Officer, Watertown Arsenal, speak on Mar. 26 at 7:45 p.m. The subject of the evening will be "Examining Steel by Use of X-Ray Spectroscope."

The New Haven Section of the A.S.M.E. with the engineers of the State of Connecticut will hold a get-together dinner meeting on March 18, at the Hotel Garde, New Haven. "The Part that Production Has Played in the Permanency of Nations," will be the subject of Ira N. Hollis, president of the Worcester Polytechnic Institute and "America the Land of Opportunity," will be the title of the speech to be made by J. L. Davis, of New Britain.

The American Chemical Society will have, at its annual meeting at Washington, D. C., April 21-26, several papers and symposiums that will be of interest to readers of Power as follows:

Division of Industrial Engineering Chemistry will hold a symposium on April 22 on the subject of "Heat Transfer," with Prof. W. H. McAdams, of the Massachusetts Institute of Technology as chairman; the Petroleum Division will have a symposium on "Turbine Oils," G. A. Burrell, Pittsburgh, chairman; the Section of Gas and Fuel Chemistry will have a symposium on "Spontaneous Combustion of Coal and Classification of Coal." On Tuesday evening there will be shown the U. S. Geological Survey motion-picture film of the Grand Canyon of the Colorado. One of the members of the survey party that made the trip through the canyon this summer will describe his experiences.

Coming Conventions

American Association of Oil Burner Manufacturers. No. 518 Bank of Galesburg Bldg., Galesburg, Ill. First annual meeting at Hotel Chase, St. Louis, Mo., April 1-3.

American Electrochemical Society. C. G. Fink, Columbia University, New York City. Meeting at Hotel Bellevue-Stratford, Philadelphia, Pa., April 24-26.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Spring convention at Birmingham, Ala., April 7-10.

American Society of Civil Engineers. John H. Dunlap, 29 West 39th St., New York City. Spring meeting at Atlanta, Ga., April 9-12.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Spring meeting at Cleveland, Ohio, May 26-29.

American Water Works Association. J. M. Diven, 153 West 71st St., New York City. Annual convention at New York City, May 19-21.

Association of Iron and Steel Electrical Engineers. W. M. Chandler, 708 Empire Building, Pittsburgh, Pa. Fuel Saving Conference—Combustion Engineers, April 2-3 at Wm. Penn Hotel, Pittsburgh, Pa.

Eastern Ice Manufacturers' Association. W. H. Ross, 35 Warren St., New York City. Spring meeting at Hotel Adelphia, Philadelphia, Pa., April 2-3.

Electric Power Club. S. N. Clarkson, Keith Bldg., Cleveland, Ohio Meeting at Seaview Golf Club, Absecon, N. J., May 26-29.

International Railway Fuel Association. J. B. Hutchinson, 6000 Michigan Ave., Chicago. Annual convention at Hotel Sherman, Chicago, Ill., May 26-29.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Meeting at Chicago, May 20-23, 1924.

National Association of Stationary Engineers. Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Grand Rapids, Mich., Sept. 8-13. Annual conventions and exhibitions of the state associations are scheduled as follows: **Kansas Association** at Parsons, Kans., April 16-18. J. M. VanSant, 739 Horne St., Topeka, Kan. **Indiana Association** at Lafayette Ind., May 5-6. Prof. A. W. Cole, Purdue University, Lafayette, Ind. **New Jersey Association** at Newark, June 6-8. Joseph P. Flynn, 612 Franklin St., Elizabeth, N. J. **Iowa Association** at Sioux City, June 10-14. Abner Davis, 16 Water house Block, Cedar Rapids, Iowa. **Ohio Association** at Akron, June 19-21. T. S. Garrett, 2622 East Second St., Dayton, Ohio. **Connecticut Association** at Bridgeport, Conn., June 27-28. George F. Klopfer, 30 East Pearl St., New Haven, Conn. **New England States Association** at Cambridge, Mass., July 10-12. Freeman L. Tyler, 32 Briggs St., Taunton, Mass. **Minnesota Association** at Fairbault, Minn., July 31, Aug. 1-2. C. A. Nelson, 800 22 Ave., N. E. Minneapolis. **Michigan Association** at Grand Rapids, Sept. 8. Wm. H. Yeomans, 209 Plainfield Ave., Grand Rapids.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St. New York City. Annual convention at Atlantic City, Young's Million-Dollar Pier, May 19-24. **Nebraska Section,** H. M. Davis, Banker's Life Bldg., Lincoln, Neb. Sectional meeting at Omaha, May 8-9. **Southwestern Division,** S. J. Ballinger, San Antonio Public Service Co., San Antonio, Texas. Divisional meeting at New Orleans, April 22-25.

Society of Industrial Engineers. George C. Dent, 608 South Dearborn St., Chicago, Ill. Eleventh annual convention at Buffalo, N. Y., April 30 to May 2, 1924.

Personal Mention

Robert F. Bohn, who has been associated with the engineering department of the Southern California Edison Co., Los Angeles, for several years, has affiliated himself with the Southern Sierras Power Co. as assistant engineer in the Imperial district.

Edwin Farnham Greene, president of Lockwood, Greene & Co., and Mrs. Greene sailed on Feb. 23 from New York City on the "Conte Rosso" for Gibraltar. They plan to visit Madrid, Paris and London before returning to the United States in April.

Obituary

Charles H. Lake, who had been employed as chief engineer by the Consolidated Power & Light Co., Kenova, West Va., for 36 years, dropped dead on the morning of Feb. 13 at the Kenova plant. His death was caused by heart failure brought on by overexertion and the excitement of a fire that was in progress at the time in the transformer yard adjacent to the station.

Business Notes

The Coppus Engineering Corp., Worcester, Mass., is now represented in the Chicago territory by the Himelblau, Agazim & Co., 30 North Dearborn St.

The Henry Pratt Co., Chicago, Ill., manufacturer of the Phillips rubber expansion joint, will have associated with it W. H. Phillips who was connected for eighteen years with the Worthington Pump & Machinery Corp. in its Chicago office.

The Pioneer Rubber Mills, 345-353 Sacramento St., San Francisco, Calif., manufacturer of packing, rubber belting, etc., has added many new buildings to its plant, during 1923, and also has erected an office building at 353 Sacramento St., San Francisco.

The McClave-Brooks Co., Scranton, Pa., announces that the George W. Akers Co., 3000 Grand River Ave., Detroit, Mich., is new sales agent for the company at Detroit; that the Chicago office has been moved from the Hearst Bldg. to 501 Chicago Trust Bldg., Chicago.

The General Electric Co., Schenectady, N. Y., announces that its east central district office will be moved from Cincinnati to Cleveland and that the local office at Cleveland will be combined with the district office. The new address will be the Union Trust Co. Building, Cleveland, Ohio.

The Falk Corporation, Milwaukee, Wis., manufacturer of gears and couplings, announces the appointment of E. C. Myers to the San Francisco office, with headquarters at 320 Rialto Bldg., and the appointment of Charles C. Walsh to the Detroit office, which is at 1500 Real Estate Exchange Bldg.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Feb. 25, 1924	Mar. 3, 1924
Pool 1	New York	$3.25	$3.25
Smokeless	Columbus	2.25	2.25
Clearfield	Boston	2.40	2.40
Somerset	Boston	2.65	2.50
Kanawha	Columbus	1.75	1.75
Hocking	Columbus	2.00	2.00
Pittsburgh No. 8	Cleveland	1.85	1.85
Franklin, Ill	Chicago	2.50	2.50
Central, Ill	Chicago	2.25	2.25
Ind. 4 h Vein	Chicago	2.75	2.50
West Ky	Louisville	1.90	1.90
S. E. Ky	Louisville	2.00	2.00
Big Seam	Birmingham	1.85	1.85

FUEL OIL

New York—March 6, light oil, tank-car lots, 28@34 deg. Baumé, 5c. per gal., 36@40 deg. 5¼c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Feb. 26, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.95 per bbl.; 26@28 deg., $2; 28@30 deg., $2.05; 32@36 deg., gas oil, 5¼c. per gal.; 38@40 deg., 6¼c. per gal.

Pittsburgh—Feb. 28, f.o.b. local refinery, 30@34 deg., fuel oil, 5¼c. per gal.; 36@40 deg., fuel oil, 6c.; 34 deg., neutral, 10c. per gal.

Cincinnati—Feb. 25, tank-car lots, f.o.b. local refinery, 26@30 deg. Baumé, 6¼c. per gal.; 30@32 deg., 6¾c.; 38@42 deg., distillate, 7½c. per gal.

Dallas—Feb. 29, f.o.b. local refinery, 26@30 deg., $1.30 per bbl.

Philadelphia—Feb. 29, 28@30 deg., $2.31@$2.36 per bbl.; 18@22 deg., $2.10@$2.16½; 13@16 deg., $1.68@$1.74½ per bbl.

Boston—Feb. 28, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4¼c. per gal., light oil, 28@32 deg. Baumé, 6¼c. per gal.

Chicago—Feb. 18, 24@26 deg., $2.12 per bbl.; gas oil, 32@36 deg., 4.93c. per gal.

New Plant Construction

Ala., Montgomery—The Atlantic Ice & Coal Corp. has plans completed for the erection of a new ice-manufacturing plant on local site, estimated to cost about $40,000. A. B. Pope is manager in charge.

Ark., Hot Springs National Park—The Baptist National Hospital Association plans for the construction of a boiler plant at its proposed local eight-story hospital, to cost about $2,000,000, for which plans are being completed by H. T. McGee, 632 Madison Avenue Building, Memphis, Tenn. Col. J. R. Fordyce, Hot Springs, Ark., is in charge.

Calif., San Francisco—The United States Navy Pay Office will take bids at once for 10 portable tachometers, as specified in N. S. A. F. req. 1625.

Calif., Fort Miley—The quartermaster, United States Army, has plans nearing completion and will soon take bids for the conversion of the present oil-burning pumping plant into an electric-operated station.

Calif., Porterville—The Valdalia Irrigation District has approved a bond issue of $210,000, for the construction of a new system, to include a number of electric-operated pumping plants.

China, Mukden—The Philadelphia Commercial Museum, Foreign Trade Department, Thirty-fourth Street, Philadelphia, Pa., has received an inquiry (No. 42025) from Tang-Wai Co., 58 Wan Shau Tsi Hutung, Mukden, for equipment for a municipal electric power plant for use in a community of about 5,000 persons, to provide for about 15,000 lamps. Further information on application.

Colombia, Bogota—The General Railway Board, Pacific Railway, plans for the construction of a power house at the proposed railway repair shops at Cali, estimated to cost $250,000, for which bids will soon be asked.

Conn., New Haven—The Hygienic Ice Co., 881 State Street, has plans nearing completion for the construction of a two-story addition to its ice-manufacturing plant, estimated to cost approximately $115,000.

Del., Wilmington—The Pyle Leather Co., Hamilton Park, is reported to be planning for the construction of a boiler plant in connection with the proposed rebuilding of its tannery, destroyed by fire, Feb. 27, with loss estimated at $100,000. Henry V. Pyle is one of the heads of the company.

Fla., Orlando—The Rose Investment Co., Walter W. Rose, is considering the installation of electric-operated pumping equipment at its proposed waterworks for service on a local tract of property being developed for residential purposes.

Fla., Palmetto—John W. Jackson, Palmetto, is planning for the purchase of air compressors for a local installation.

Fla., Pensacola — The Pensacola Gulf Beach Co. plans for the construction of a power house at its proposed 300 room hotel on local site, to cost in excess of $1,000,000. Theodore Baars is president.

Fla., Tampa—William Byms, P. O. Box 2611, has inquiries out for power equipment for installation at a rock quarry in this section, to be used for drilling and other operating service

Fla., West Palm Beach—Ralph B. Wagner, 1409 Florida Avenue, operating the local gas works, recently purchased, plans for the installation of additional boilers and other power equipment.

Ga., Garfield—J. B. Fields, Garfield, is in the market for a return tubular boiler and auxiliary equipment for local service.

Ga., Thomasville—The City Council will receive bids until March 24, for equipment for the water and light department, including one steam turbine, 700 kw, capacity, with generator and accessories; also, for steam boiler and auxiliary apparatus. E. M. Smith, Jr., is city clerk. D. Rhett Pringle is superintendent of the water and light department.

Idaho, Boise—The United States Senate, Washington, D. C., has approved an appropriation of $450,000, for the construction of a hydro-electric power plant in connection with the Government reclamation project in this district. The Bureau of Reclamation, Denver, Colo., will be in charge.

Iowa, Cedar Rapids—The Penick & Ford Co., manufacturer of food products, has tentative plans for the rebuilding of the portion of the power station at its local factory, destroyed as a result of an explosion, with loss estimated at $35,000, including heavy damage to a turbine unit. Headquarters of the company are in the Whitney Building, New Orleans, La.

Iowa, Clutier — The Town Council will soon call for bids for a steel water tank and tower for the municipal waterworks. J. J. Lusk is clerk.

Iowa, Sioux City—The Sioux City Gas & Electric Co. has arranged a bond issue of $2,550,000, practically the entire proceeds to be used in connection with a proposed steam-operated generating plant on the Big Sioux River, with initial capacity of 22,500 kw., for which plans are being perfected. The station will have an ultimate output of 67,500 kw. L. L. Kellogg is president.

Ky., Paintsville—The Louisville Gas & Electric Co., Louisville, Ky., has tentative plans under consideration for the rebuilding of the portion of its local pumping plant, recently destroyed by fire, with loss reported at $15,000.

Me., Oakland—The Central Maine Power Co., Augusta, Me., is said to be perfecting plant for the erection of a new power plant on local site, to cost in excess of $100,000. W. S. Wyman is general manager.

Md., Baltimore — The Board of Public Works, City Hall, has plans in preparation for the installation of a pumping plant for sludge service at the Back River sewerage station, estimated to cost $40,000. Milton J. Ruark, 311 St. Paul Street, is engineer.

Md., Baltimore—The William Schluderberg-T. J. Kurdle Co., Baltimore and Fifth Streets, meat packer, plans for the installation of a cold storage and refrigerating plant in a new three-story addition to cost close to $400,000. C. B. Comstock, 110 West Fortieth Street, New York, is engineer.

Mass., Beverly—The Beverly Coal Co. has commenced the construction of a new coaling plant at River and Pleasant Sts., with capacity for handling 1,000 tons, to include the installation of coal-handling apparatus, conveyors, elevators, etc., estimated to cost about $22,500. George P. Carver, 261 Franklin Street, Boston, is architect.

Mass., Boston — The Boston Elevated Railway Co., 108 Massachusetts Avenue, has made application for permission to issue bonds for extensions and betterments, to include a fund of $3,000,000 for work at the South Boston power station, including boilers and auxiliary apparatus, electric equipment, etc. James F. Jackson is chairman of the board of trustees.

Mexico, Tampico—The Mexican Petroleum Co., Ltd., 120 Broadway, New York, N. Y., operated by the Pan-American Petroleum & Transport Co., same address, will install a pumping plant, two reheating plants and booster power station in connection with its proposed pipe line from Ebano to the tank storage plant at Tankville, near Tampico.

Mich., Alston—The General Lumber Co., Milwaukee, Wis., is said to be planning for the construction of a boiler plant at its local mill, comprising the former works of the Rubicon Lumber Co., recently acquired, in connection with the erection of a new planing mill, shingle mill and other structures, estimated to cost $90,000.

Minn., Detroit—The Common Council, E. J. Bestick, clerk, has commissioned L. P. Wolfe, 1000 Guardian Life Building, St. Paul, Minn., engineer, to prepare plans for the proposed addition to the municipal electric plant, one-story, estimated to cost $60,000. A list of equipment to be installed will soon be arranged.

Minn., Duluth—Plans are under consideration for extensions and improvements in the municipal waterworks, to include the installation of additional electric-operated pumping machinery and auxiliary apparatus. The Gary Advancement Club and the New Duluth Commercial Club are interested in the project.

Minn., Paynesville—The Common Council is considering the installation of electric-operated pumping equipment in connection with a proposed waterworks, for which preliminary plans have been prepared by Druar & Milinowski, 500 Globe Building, St. Paul, Minn., consulting engineers.

Miss., Magee—The Board of Aldermen has tentative plans under consideration for the installation of electric-operated pumping equipment in connection with a proposed municipal waterworks, estimated to cost in excess of $50,000.

Miss., Meridian—The City Council contemplates the installation of electric-operated pumping equipment in connection with proposed waterworks and sewerage extensions and improvements, for which a bond issue of $121,750 has been sold.

Miss., **Tupelo**—The Mississippi Light & Power Co., Jackson, Miss., has preliminary plans for enlargements of its power plant in this vicinity to more than double the present output. H. M. Couch is president.

Miss., Vicksburg—James J. and John T. Corrigan, Vicksburg, will make extensions and improvements in a local building for the installation of an ice-manufacturing plant, with initial capacity of about 25 tons per day.

Mo., St. Joseph—The Missouri Rubber Products Co., 317 Kirkpatrick Building, plans for the construction of a boiler plant at its proposed local one and three-story mill at Garfield and Twenty-second Streets, estimated to cost $500,000. E. C. Lowe, company address, is engineer. H. D. Auerbach is president.

N. H., Portsmouth—The Bureau of Supplies and Accounts, Navy Department, Washington, D. C., will take bids until March 18, for a quantity of miscellaneous air pressure gages for the local navy yard, as set forth in Schedule 1950.

N. J., Hightstown — The Board of Trustees, Peddie Institute, plans for the early construction of a power house at the institution, for which plans have been prepared by W. E. S. Dyer, Land Title Building, Philadelphia, Pa.

N. J., Dunellen—The Dunellen Ice Co. has completed plans for the erection of a new one and two-story ice-manufacturing plant, 100 x 100 ft., and plans to commence work at an early date. Frank H. Quinby, 110 William Street, New York, is architect.

N. Y., Brooklyn — The State Arsenal Commission, Albany, will install a steam power plant in the new state arsenal to be erected on the block bounded by Second and Third Avenues, Sixty-third and Sixty-fourth Street, 100 x 400 ft., to cost in excess of $1,200,000, for which bids will be asked about March 15. Sullivan W. Jones is state architect.

N. Y., Oakfield—The United States Gypsum Co. plans for the immediate rebuilding of the portion of its power station, recently destroyed through the bursting of a flywheel. Equipment will be installed to replace damaged apparatus.

N. Y., New York—The Bureau of Yards and Docks, Navy Department, Washington, D. C., has plans in progress and will soon take bids for ash-handling equipment for local service, as set forth in Specification 4959.

N. Y., New York—C. S. White, purchasing agent of the New York Central Railroad Co., 466 Lexington Avenue, will take bids until March 14, for one 2,500 kw. synchronous converter, one 2,000 kw. motor-generator set, and auxiliary equipment, as set forth in Serial Contract No. 6-1924.

N. Y., Raybrook — The State Hospital Commission will hold in temporary abeyance the construction of the proposed cold storage plant at the local state tuberculosis hospital, and will take new bids on equipment at a later date. Sullivan W. Jones is state architect.

N. C., Gastonia — The Gastonia Brick Co., recently formed, plans for the construction of a power house at its proposed local brick-manufacturing plant. A. B. Lewis is president.

N. C., Greensboro—The Proximity Mfg. Co. will make improvements in the electric power plant at its local textile mill, and install considerable new equipment. Awards have been made for a generator and condenser apparatus, and other orders will soon be placed for boiler room equipment and auxiliary apparatus. J. E. Sirrine & Co., Greenville, S. C., are engineers.

N. C., North Wilkesboro — The City Council will break ground at once for its proposed municipal power plant, for which a general building contract has been awarded to Foster & Allen, North Wilkesboro.

N. C., Robersonville—The Common Council plans for the installation of electric-operated pumping equipment at the proposed waterworks, for which it is expected to take bids in April. The Carolina Engineering Co., Wilmington, N. C., is engineer.

N. C., Rocky Mount — The Board of Aldermen will receive bids until March 26, for equipment for a municipal power plant, including 2,500 kw. turbo-alternator; surface condenser; two 750 hp. watertube boilers; centrifugal and other pumps; underfeed mechanical stokers; radial brick stack, 225 ft. high; 30-ton electric-traveling crane, and complete auxiliary power equipment. William C. Olson, Raleigh, N. C., is consulting engineer. C. H. Harris, city clerk.

N. S., New Brunswick—The Power Department of the Provincial Government is considering plans for the construction of a hydro-electric power plant at Grand Falls, St. John River, estimated to cost in excess of $500,000.

N. S., Yarmouth — The Yarmouth Cold Storage Co., Ltd., has preliminary plans under way for the erection of a new cold storage and refrigerating plant, estimated to cost in excess of $125,000.

Ohio, Cincinnati—The Columbia Gas & Electric Co. is arranging a fund of $25,000,000, a large part of the proceeds to be used for the construction of its proposed steam-operated generating plant at Fort Miami, on the Great Miami River, for which preliminary site clearing and foundation work are being placed under way.

Okla., Enid—The Board of City Commissioners plans for the installation of a 150 hp. boiler at the municipal waterworks, with auxiliary equipment, and will take bids at an early date.

Okla., Pawhuska—The Common Council is perfecting plans for the installation of additional equipment at the municipal power station, including Diesel engine, oil-operated with electric generator and auxiliary apparatus.

Pa., Mercer — The City Council contemplates the installation of a pumping plant in connection with a proposed sewerage disposal works, to cost about $25,000. John M. Rice, Oliver Building, Pittsburgh, Pa., is consulting engineer.

Pa., Philadelphia — The Atwater-Kent Mfg. Co., 4937 Stenton Avenue, manufacturer of radio apparatus, etc., plans for the construction of a boiler plant at its proposed new works at Wissahickon Avenue and Abbottsford Road, estimated to cost $1,000,000, on which construction will proceed at once.

Pa., Pittsburgh—The D. L. Clark Co., Martindale Street, manufacturer of confectionery products, plans for the installation of a boiler plant in its proposed six-story factory at Martindale and Reedsdale Streets, estimated to cost $325,000, for which plans are nearing completion. Peter Dietz, Lyceum Building, is engineer. D. L. Clark is president.

Pa., Pleasant Gap — The Whiterock Quarries are planning for the installation of air compressor equipment, conveying apparatus, etc. A fund has been arranged for improvements.

Pa., Pottsville — The Pottsville Water Co. is considering the installation of electric-operated pumping equipment for service in connection with its proposed reservoir in the Indian Run section, with capacity of 500 million gals., to cost approximately $1,000,000.

S. C., Bamberg—The Board of Public Works plans for the early purchase of equipment for installation in an addition to be constructed to the municipal power plant, consisting of two 150 hp. oil-operated engine-generator sets, with 125 kva. generator and auxiliary equipment. L. P. Tobin is superintendent.

S. C., Chester—Ira A. Smith, Chester, and associates are planning for the construction of a power house in connection with their proposed fertilizer plant, reported to cost in excess $50,000.

S. C., Mullins—The Mullins Lumber Co. is planning for the purchase of an automatic engine and auxiliary equipment for its power department.

Tenn., Chattanooga — The Tennessee Electric Power Co. is said to have tentative plans under way for additions in its power plants, and will use a portion of a recent bond issue of $3,000,000, for the expansion.

Tenn., Cleveland—The Cleveland Woolen Mills, Inc., will proceed at once with the erection of the proposed steam-operated electric power plant at its local textile mills, to furnish all power requirements for operation. A 150 ft. high radial brick stack will be constructed. W. H. Sears, Chattanooga, Tenn., is architect.

Tex., Brady—The City Council plans for the installation of additional pumping machinery and auxiliary power equipment in connection with proposed extensions in the waterworks, estimated to cost $100,000. A bond issue will soon be arranged.

Tex., Houston—The Mid-Continent Rubber Co., Bankers' Mortgage Building, W. D. Horton, president, is considering the installation of a power house at its proposed local plant for the manufacture of automobile tires, etc., estimated to cost in excess of $1,000,000.

Tex., Jacksonville—The Florida Paper Mills, Inc., operated by the Grass Fibre Pulp & Paper Corp., Leesburg, Fla., plans for the construction of a power house at its local mill, for which erection plans are maturing and work on initial units to commence soon. It will cost in excess of $400,000, with machinery. Gilbert Leach is treasurer of the parent organization.

Tex., Mart—The Common Council will soon take bids for equipment for the proposed municipal waterworks station, including motor-driven or oil-operated centrifugal pumping machinery for a capacity of 1,000,000 gal. per day. The entire project will involve $150,000. Koch & Fowler, Dallas, Tex., are engineers.

Tex., San Juan—The Rio Grande Valley Canning & Packing Co., recently formed by J. B. Hampton, Commerce, Tex., and associates, plans for the construction of a steam power house at its proposed local canning plant, for which plans will soon be perfected.

Tex., Spur—The Spur Light & Power Co. has tentative plans under advisement for the installation of an ice-manufacturing plant, estimated to cost in excess of $45,000, with equipment.

Tex., Texas City—The Knox Process Corporation will install air compressors, engine equipment and other power apparatus at its proposed local gasoline refining plant, estimated to cost $1,200,000.

Tex., Waco—The Calcium Arsenate & Lime Co. has tentative plans for the construction of a boiler plant at its proposed local hydrated lime and calcium arsenate works, to cost approximately $150,000. The plant will be located at Leon Junction. S. C. Williams is president.

Va., Bristol—The Bristol Coal & Ice Co., Inc., has preliminary plans under consideration for the construction of a cold storage plant, to be operated in conjunction with an ice-manufacturing plant, recently completed. R. F. Wagner is head.

Va., Staunton—A bond issue of $700,000 has been approved for the installation of a municipal waterworks, to include a boiler plant and pumping station, with steam or electric-operated centrifugal pumping equipment. Fuller & McClintock, 170 Broadway, New York, are engineers. W. F. Day is city manager in charge.

Wash., Tacoma—The City Council will call for bids about March 15 for the construction of the initial unit of the municipal power project at Lake Cushman, consisting of hydro-electric generating station with capacity of 50,000 hp., estimated to cost $525,000. The ultimate development will total 140,000 hp. J. L. Stannard is chief engineer.

Wash., Seattle—The Puget Sound Light & Power Co. is said to have secured permission to construct a hydro-electric power plant on the Baker River in Skagit County, and will proceed with the development at an early date. The plant will have a capacity of 45,000 hp., and will cost close to $4,000,000. The company is operated by the Stone & Webster Management Corporation, 147 Milk Street, Boston, Mass.

W. Va., Clarksburg—The People's Home Corporation plans for the construction of an electric light and power plant for service on a tract of 150 acres of land, to be developed for residential purposes. Richard Scott is secretary.

W. Va., Huntington—The Chesapeake & Ohio Railroad Co., Richmond, Va., is said to be planning for the construction of a power house at its proposed local locomotive and car repair shops, to cost approximately $2,000,000.

W. Va., Point Pleasant—The Common Council is considering the installation of electric-operated pumping equipment in connection with a proposed new sewerage system, estimated to cost in excess of $65,000.

Wis., Kenosha—The St. Catherine's Hospital, operated by the Dominican Sisters, Milwaukee Avenue, is having plans drawn for the construction of a power house at its proposed local institutional building, estimated to cost $300,000. Berlin & Swern, 19 South La Salle Street, Chicago, Ill., are architects and engineers.

Wis., Kohler—The Common Council, Edwin Albrecht, clerk, will receive bids until March 17, for an elevated steel tank, 100,000 gals. capacity, on 100 ft. steel tower. Jerry Donohue, Sheboygan, Wis., is engineer.

Wis., Phillips—The City Council will rereceive bids until 7:30 p.m., March 14, for equipment for the municipal pumping plant (previously called on Feb. 21, and advanced), including one reciprocating pump, 300 gal. per min. capacity, with motor drive; one centrifugal pump, 1,000 gal. per min. capacity, motor drive; and gasoline engine stand-by, with all necessary electrical equipment and auxiliary work. Also, for a steel storage tank on steel tower; and automatic controlling valve and similar apparatus. Druar & Milinowski, 500 Globe Building, St. Paul, Minn., are consulting engineers. Carl F. Scheel, city clerk.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Advances—Trend of hose and belting prices upward. Packing and pipe covering firm at present levels. Linseed oil rose 2c. in New York and 4c. per gal. in Cleveland during month. Rising pig lead prices reflected in advance in white lead quotations; red lead also higher. Babbitt metal up in New York and Cleveland owing to recent rise in non-ferrous metals. Rubber covered copper wire prices 5 per cent above one month ago.

Declines—Structural and boiler rivets about 15c. per 100 lb. under month ago at Pittsburgh mill. No other declines of importance.

POWER-PLANT SUPPLIES

HOSE—

Fire	50-Ft. Lengths
Underwriters' 2½-in., coupled	61c. per ft.
Common, 2½-in., 3-ply ... $1.00 per ft. list less	40%

Air—Best grade

¼-in., per ft.	3-ply ... $0.36	4 ply ... $0.44½

Steam—Discounts from List

First grade ... 30% Second grade ... 40% Third grade ... 40-5%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Second grade ... 50-5% Best grade ... 50%

LEATHER BELTING—List price, 2c. per sq. in., per ply.

Grade	Discount from list
Medium	40-2½%
Heavy	30-5%

RAWHIDE LACING { For cut, best grade, 45-5%, 2nd grade, 55%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 45-5%; sides, 41c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam, ½ in.	$0.90
Asbestos for high-pressure steam, ½ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@$2.60 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.64 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	14@21	20.00	14.00
Colored	9@12½	17.00	10.50

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13¼ x 13¼	13¼ x 20½
Chicago	16.00	16.00
New York	11.00	11.50
Cleveland	$36.00 per M.	$52.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.97	$1.04	$0.94

WHITE AND RED LEAD—In 100-lb. kegs, base price in cents per pound:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	15.00	14.25	16.50	15.75
White	15.00	14.25	15.00	14.25

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅛ and smaller	50%	60%	60%
Tinned	50%	60 & 4½c. per lb. net	

Structural rivets, ½ and ¾, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York ... $4.40 Chicago ... $3.75 Pittsburgh ... $2.75

Boiler rivets, same sizes:

New York ... $4.50 Chicago ... $3.85 Pittsburgh ... $3.00

REFRACTORIES—Prices in carlots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$50@55
Chrome cement, 40@50% Cr_2O_3, in bulk	net ton	27@32
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	31@36
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Mt. Union, Pa.	per M	42.00@43.50
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	41@48
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	42@43
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	42@43
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	36@43
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	37@39
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	37@39
Chrome ore crude, 40@50%	net ton	18.00@23.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	60.00	65.00	48@52
(35% tin)	28.00	21.50	22@25

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.40	$3.90	$4.30
Flats, square and hexagons, per 100 lb. base	4.90	4.40	4.80

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
4	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	$0.26	$0.29	.23
1	.20	.25	.21
1¼	.23	.29	.23
1½	.24	.33	.28
2¼	.....	.....	.....
2	.30	.41	.32
2¼	.32	.47	.35
3¼	.34	.51	.37
2	.43	.64	.47

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special engths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2½ in. diameter, 7c. per cut
2¾ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3¼ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 43.50 (net)	$ 70 00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

		Lead Covered
Less than coil lots	35%	20%
Coils to 1,000 ft.	45%	25%
1,000 to 5,000 ft.	50%	30%
5,000 ft. and over	55%	35%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
⅛	$61.10	$66.16	$9.90	$11.03	$5.74	$6.16
¼	79.20	84.95	13.00	14.49	8.18	8.78
⅜	112.06	122.19	19.26	21.46	10.65	11.42
½	151.62	165.31	25.65	28.33	14.76	15.78
¾	181.28	197.67	34.19	37.77	18.23	19.47
1	248.90	265.94	62.70	69.24	24.29	25.97
1¼	385.50	420.48	102.58	111.33	34.71	37.10
1½	504.29	548.81	273.40	302.12	51.66	55.63
1¾	633.86	688.65	604.03	667.15	69.41	74.19
2	772.62	838.59	697.06	770.99	86.76	92.73

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.47	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$22.00
No. 16 cotton reinforced heavy	25.50
No. 18 cotton reinforced light	19.00
No. 16 cotton reinforced light	21.50
No. 18 cotton Canvasite cord	16.50
No. 16 cotton Canvasite cord	18.75

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60-amp.	100	.30	35-amp. to 60-amp.	100	.60
61-amp. to 100-amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.70
0-30 ampere, less than standard package	3.00

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.30	$0.35	120	50	$0.45	$0.45	60
15	.30	.35	120	75	.50	.55	60
25	.30	.35	120	100	.60	.65	24
40	.30	.35	120	150	.75	.80	24
50	.30	.35	120	200	1.00	1.10	24
60	.35	.40	120	300	1.60	1.70	24
				500	2.35	2.50	12
				750	3.75	3.95	8
				1,000	4.00	4.25	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $75.00 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Composition—2 Pc. Plug—Composition	0.8½

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o b. New York,

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 7.35	$ 9.98	$13.12	$18.74
12	9.97	12.86	14.59	24.57
10	13.33	16.69	18.79	30.45
8	18.27	21.78	23.36	40.95
6	.....	.....	34.36	.....
4	.....	.....	46.72	.....
2	.....	.....	68.14	.....
1	.....	.....	89.77	.....
0	.....	.....	119.70	.....
00	.....	.....	138.60	.....
000	.....	.....	166.95	.....
0000	.....	.....	198.45	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	½ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.55	$0.39	$0.36	$0.61

Less 1-5th standard package	25%
1-5th to standard package	32%
Standard package	37%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c. or a.c., N E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25 to $50 list value	30–5%
$50 list value or over	35%